

Principles for the Development of a Complete Mind:

Study the science of art.

Study the art of science.

Develop your senses - especially learn how to see.

Realise that everything connects to everything else

- Leonardo Da Vinci

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Understanding Sensory Analysis in Consumer-Driven Product Development in Chocolate Confectionary

Thesis submitted in fulfilment of the requirements
for the degree of Doctor (PhD) in Applied Biological Sciences

Dutch translation of the title:

Inzicht in de rol van sensorische analyse in consumenten gedreven product ontwikkeling binnen de chocolade sector.

Suggested way of citation:

De Pelsmaecker, S. 2016. Understanding Sensory Analysis in Consumer-Driven Product Development in Chocolate Confectionary. Doctoral Dissertation, Ghent University

ISBN-number: 978-90-5989-868-4

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Acknowledgements

Om het met de woorden van Erik van Looy te zeggen: 'T IS GEBEURD!

Wat begon in 2009 als een sprong in het onbekende, eindigt hier met een document waarin ik naast het wetenschappelijk verhaal ook een deel van mijn persoonlijke overtuiging en passie heb gelegd. Ik zal pas echt mijn doel bereikt hebben indien ik iedereen dit boek ter hand neemt, ervan kan overtuigen dat sensorische analyse echt een plaats verdient in productontwikkeling.

Ik herinner mij nog de mail van Prof. Gellynck waarin hij vroeg eens langs te komen op zijn bureau in verband met een nieuw project genaamd 'ProPraline'. Na mijn stage bij Callebaut, mijn vakken binnen de voeding en de lessen die ik gevolgd had omtrent consumentengedrag en sensorische analyse was ik misschien wel geïnteresseerd om op dit project te komen werken. Tijdens ons gesprek kwam ook de optie om een doctoraatstudie te doen aan bod. Iets waar ik nooit had bij stilgestaan! Ik kon er natuurlijk over nadenken, maar liefst binnen de week een antwoord geven! En zo begon mijn eigen PhD-tocht...

Als doctoraatsbursaal zocht ik de eerste twee jaren mijn weg in de wetenschappelijke wereld en maar ook in het schrijven en uitvoeren van projecten. Het was een tocht met vele ups en downs waarin het meermaals door mijn hoofd spookte om een andere weg in te slaan. Maar gaandeweg werd er data verzameld, drafts van artikels geschreven en zelfs een project binnengehaald. Op één van de moeilijkste momenten in de voorbije jaren kreeg ik een kans om naar het buitenland te trekken en daar een stage te gaan doen in een multinational. Dit werd één van de meest verrijkende ervaringen in mijn leven. Ik keerde terug als '*a person full of inspiration and vision*' (quote Dr. Dora). Het is die visie die mij hier vandaag gebracht heeft.

Ik zette mijn PhD-tocht verder, ditmaal als assistent (of AAP-er). Naast het doctoraatsonderzoek, uitvoeren van projecten stond ik nu ook in voor ondersteuning bij onderwijstaken waarbij fungeerde ik als directe lijn tussen de studenten en Prof. Gellynck. Hierdoor beschik ik nu over een arsenaal aan grappige verhalen, zeer familiale of onbeschofte mails maar ook mooie momenten waarin je studenten tegenkomt die zichzelf ontplooiën tot echte bio-ingenieurs. Ook het hele SensoLab-verhaal heeft mij gedurende de jaren steeds geïnspireerd en mijn passie voor sensorische analyse en productontwikkeling steeds gevoed. De vele projecten waarop ik door de jaren heen gewerkt hebt, zorgden er ook voor dat ik steeds nieuwe dingen leerde kennen waardoor mijn honger naar verruiming van mijn kennis steeds gestild werd.

Vandaag is die PhD-tocht ten einde en wil ik toch van de gelegenheid gebruik maken om enkele mensen te bedanken die van dicht of veraf bijgedragen hebben tot dit werk.

Eerst en vooral mijn beide promotoren, Prof. Gellynck en Prof. Dewettinck. Xavier, bedankt voor alle kansen die je mij de laatste jaren gegeven hebt. Ik heb steeds heel veel vrijheid gekregen in zowel mijn onderzoek als mijn projecten. Ook onze samenwerking voor het onderwijsgedeelte liep steeds vlot ondanks de soms krappe deadlines. Ik ga er van uit dat dit voortvloeide uit een vertrouwen in mijn kunnen en hoop dan ook van harte dat ik dit vandaag heb kunnen waarmaken. Koen, vroeger copromotor, nu promotor, ook jij stond steeds klaar indien er vragen of moeilijkheden waren omtrent technologische aspecten van mijn onderzoek. Ook via het Cacaolab heb je een zeer substantiële bijdrage geleverd aan het werk dat hier vandaag wordt afgerond. Beide wil ik jullie tevens uitdrukkelijk bedanken voor de uitbouw en ondersteuning van het SensoLab.

Bedankt ook aan de leden van de examencommissie om de tijd vrij te maken om dit document te beoordelen. Jullie constructieve feedback heeft zeker een waardevolle bijdrage geleverd om dit proefschrift naar een hoger niveau te tillen.

Daarnaast wil ik ook alle partners bedanken met wie ik de voorbije jaren heb samengewerkt binnen verschillende projecten: ProPraline, Smaakklassen, Smaakbeleving, Green Food Industries, Crowdsourcing, Taste2Seas en nu Finesweet. De kennis die ik heb opgedaan in deze projecten is van onschatbare waarde en hebben op één of andere manier hun weg gevonden in dit doctoraat. Ik wil jullie allen bedanken voor de goede samenwerking en hoop op deze manier verder te gaan in de toekomst.

En nu een speciale dank aan de vele collega's en ex-collega's... Waar te beginnen? Bovendien zijn ze in mijn geval dan nog verspreid over twee vakgroepen: Landbouweconomie en Voedselveiligheid en voedselkwaliteit. Hoewel mijn vaste stek op de landbouweconomie was, heb ik mij ook altijd thuis gevoeld bij de FTE's, waarvoor dank! Ook binnen onze vakgroep heb ik steeds kunnen samenwerken met toffe collega's die naast het serieuze werk ook wel tijd hadden voor een babbel voornamelijk in ons koffiekot. Of tijdens onze after-work activiteiten... Een speciale dank aan Bianka en Evelien, die gedurende de laatste vier jaar een bureau met mij deelden. Ik heb jullie met mijn verzuchtingen dikwijls van het werk gehouden maar kijk, ik ben de laatste in rij die nu Dr. voor mijn naam mag zetten, dus zo erg zal het wel niet geweest zijn... Hans, bedankt voor de continue steun bij onderzoek, projecten en onderwijsopdrachten! En dan als laatste maar zeker niet de minste: Joachim en Sofie. Vaak heb ik op jullie steun kunnen rekenen wanneer ik weer eens een massa deadlines had. Ik hoop dat we ook in de toekomst kunnen verder werken zoals we bezig zijn.

Maar om goed te kunnen werken moet er ook zo iets zijn als ontspanning. Ik vind het dan ook vanzelfsprekend dat mijn vrienden een plaatsje krijgen in dit doctoraat. Zij hebben door voor deze broodnodige ontspanning te zorgen, zeker een bijdrage geleverd aan het tot stand brengen van dit doctoraat. Hoewel de eerste jaren meer in het teken stonden van feestjes overal te lande, is het dezer dagen meer gericht op onze kleine bengels. Hoewel we er toch in slagen om toch nog regelmatig eens een 'no-kids-allowed' moment in te lassen. De laatste maanden ben ik er zeker niet altijd bij geweest, maar jullie weten allemaal dat ik dit ruimschoots goed zal maken.

Verder mijn familie, tantes, nonkels, neven en nichten. We zien mekaar zeker niet zo vaak maar toch weet ik dat op belangrijke momenten, zoals dit er eentje is, jullie allen achter mij staan en fier zijn op jullie nichtje. Mijn kinderlijke ambities om 'zangeres en danseres' te worden heb ik bij deze dan ook volledig opgeborgen maar ik denk dat de opvolging daarin verzekerd is... Mijn twee grootmoeders, meter Charlotte en meter Yvonne, jullie hebben mij zien opgroeien van een kleine spraakwaterval tot ... tja een grote spraakwaterval. Ook jullie hebben mij beide veel wijsheden bijgebracht die ik voor altijd met mij meedraag.

Graag had ik hier ook een speciaal woordje toegevoegd aan misschien wel twee van mijn grootste supporters: peter Armand en peter Frans. Hoewel jullie beiden er al niet meer waren op het moment dat ik aan deze tocht begon, weet ik met 100% zekerheid dat jullie ongelooflijk fier op mij zouden zijn.

Mijn schoonouders, schoonzus en –broer, Greta, Gino, Tara en Jan. Ik wil ook jullie graag bedanken voor de steun de afgelopen jaren. Jullie hebben mij in jullie gezin opgenomen en echt een tweede thuis gegeven. Ook zeker met alle ondernemingen naast mijn doctoraat kon ik steeds op jullie rekenen (huisje, tuintje (niet te vergeten), kindje, zelfs hondje).

Twee heel bijzondere mensen verdienen een speciale bedanking vandaag: mijn mama en papa. Wat een hele tocht is geweest voor mij, is dit zeker ook voor jullie geweest. Waar het misschien in de beginjaren allemaal redelijk vlot ging aangezien ik heel vlot van kleuterklas, naar lager onderwijs en middelbaar onderwijs ging, was het niet altijd evident tijdens mijn universiteitsjaren en later tijdens mijn doctoraatsonderneming. Maar ik heb het gehaald en eindelijk sta ik hier. Dankzij jullie onvoorwaardelijke liefde en steun, de goede zorgen en alle kansen die jullie mij gaven, kan ik onbezorgd door het leven gaan. Ik hoop dan ook dat dit doctoraat ook voor jullie een beloning is.

En om met een cliché te eindigen: *Last but not least...* Kenneth. We zijn allebei mensen van weinig woorden en toch weten we precies wat we aan elkaar hebben. Jij en ik, een onafscheidelijk duo, dat heeft het verleden ons wel geleerd. Ik durf eerlijk te zeggen dat zonder jou hier vandaag geen Dr. De Pelsmaeker zou staan. Het is jouw liefde en steun, maar ook jouw tonnen begrip, enthousiasme voor wie ik ben en wat ik doe, dat er elke dag voor zorgt dat ik het beste van mezelf wil geven. Je bent de meest fantastische echtgenoot en een geweldige papa voor ons Lauren maar bovenal mijn beste vriend. Samen hebben we al verschillende hoofdstukken van ons leven geschreven en ik denk dat we hier misschien wel eentje afronden. Ik kijk alvast uit naar het volgende waar we samen met Lauren en onze volgende bengel aan zullen beginnen...

Sara De Pelsmaeker

Februari 2016

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List of abbreviations

ACA: Adaptive conjoint analysis	NMR: Nuclear Magnetic Resonance
ACQ: Attitude to chocolate questionnaire	NPD: New product development
AE: Anticipated emotions	OLS: ordinary least squares
ANOVA: analysis of variance	PB: Premium brand
ATT: Attitude	PBC: Perceived behavioural control
BE: Belgium	PCA: principal component analysis
C*: Chroma-value	PLB: Private label brand
CA: customer attributes	PSD: Particle size distribution
CAGR: Compounded annual growth rate	QA: Quality assurance
CLT: Central Location Test	QC: Quality control
CTU: chocolate tempering unit	QDA: Quantitative Descriptive Analysis
DEBQ: Dutch Eating Behaviour	QFD: Quality Function Deployment
DH _{melt} : Melting enthalpy	Questionnaire
DSC: Differential Scanning Calorimetry	R&D: Research and Development
EC: Engineering characteristics	SFC: Solid fat content
EFA: Exploratory factor analysis	SME: Small medium enterprise
EU: European Union	SN: Subjective norm
FCQ: Food Choice Questionnaire	Standardization
h°: hue-value	TB: Traditional brand
HOQ: House of Quality	T _{end} : End temperature
HU: Hungary	TFQM: Total food quality model
HUT: Home Use Test	TI: tempering index
ICCO: International Cocoa Organisation	T _{onset} : Onset temperature
ISO: International Organization for	TPB: Theory of planned behaviour
JAR: Just-About-Right	T _{peak} : Peak temperature
L*: lightness	WI: Whiteness Index
LSD: Least-Significant-Difference	

Samenvatting

Het ontwikkelen van nieuwe producten is en blijft één van de belangrijkste doelstellingen binnen de voedingsindustrie. Mesias et al. (2013) gaf in zijn onderzoek aan dat de huidige veranderingen in consumptiepatronen aanleiding geven tot nieuwe opportuniteiten voor de ontwikkeling van nieuwe producten. Deze veranderende patronen creëren ook bepaalde uitdagingen voor de voedingsproducten. In de laatste decennia hebben verschillende studies aangegeven dat productontwikkeling een proces is waarin men moet vertrekken vanuit het standpunt van de consument (Linnemann et al., 2006, Van Trijp and Steenkamp, 1998, Craig and Hart, 1992). Om deze manier van productontwikkeling echter tot een goed einde te brengen, moet een producent voldoende kennis hebben over de complexiteit van perceptie en de voorkeur van de consument (Linnemann et al., 2006, Sijtsma et al., 2002).

Dit doctoraatsonderzoek heeft als doel de mogelijkheden te bekijken hoe sensorische analyse een rol kan spelen in het innovatieproces of dienst kan doen als een instrument om informatie te verzamelen voor de aanpassing van een voedingsproduct omtrent marketing, productkarakteristieken of procesparameters. Dit onderzoek is onderverdeeld in drie grote delen die zich richten op de sensorische evaluatie van chocoladeproducten en hoe dit gerelateerd kan worden aan procesparameters (Deel I), emoties en gedrag van de consument (Deel II) en consument-gedreven productontwikkeling (Deel III). In dit onderzoek wordt zowel primaire als secundaire data gebruikt. De primaire data wordt verzameld door zowel kwalitatief, kwantitatief en experimenteel onderzoek. De secundaire data wordt enerzijds gebruikt als input informatie voor de kwalitatieve studies en anderzijds om een overzicht te geven van het gebruik van sensorische analyse in conjoint analyse.

Er werden drie onderzoeksdoelstellingen vooropgesteld wat aanleiding geeft tot zes verschillende onderzoeksvragen. Als eerste doelstelling werd onderzocht welke de belangrijkste sensorische attributen zijn voor het definiëren van chocolade. Hieruit wordt de eerste onderzoeksvraag afgeleid: op basis van welke sensorische attributen beoordelen consumenten de kwaliteit van chocolade? Binnen hoofdstuk 2 werd duidelijk aangegeven dat het belangrijk is om hierbij vooral de verschillende smaken te bekijken en tevens de verschillende intensiteiten van textuur attributen in acht te nemen. Daarna werd nagegaan of sensorische analyse kan bijdragen tot het karakteriseren van fysische producteigenschappen. Elke studie die werd uitgevoerd in Deel I illustreert de complexiteit van chocoladeproducten en de noodzaak om zowel de sensorische eigenschappen goed te beheersen als de interactie van deze eigenschappen met procescondities en acceptatie van de consument te begrijpen. Dit geeft aan dat de complementariteit van sensorische en instrumentele metingen van grote waarde kan zijn bij het beantwoorden van specifieke onderzoeksvragen binnen een voedingsbedrijf.

De tweede onderzoeksdoelstelling is gericht op het consumentengedrag en de emoties tegenover chocoladeconsumptie. Vorig onderzoek gaf aan dat de populariteit van chocolade gerelateerd is aan de emoties die het opwekt bij de consument (Macht and Dettmer, 2006, Parker et al., 2006). Dit onderzoek focust op zowel de geanticiperde emoties als de emoties die ervaren worden tijdens en na het consumeren van chocolade. De resultaten geven aan dat de geanticiperde emoties een impact hebben op de intentie om chocolade te eten en eveneens op het eigenlijk gedrag van de consumenten. Dit onderzoek heeft daarenboven aangetoond dat het consumptiegedrag van de Belgische en de Hongaarse consumenten gebaseerd is op verschillende overtuigingen betreffende chocolade. Een goed begrip van deze verschillen kan zeer waardevolle informatie zijn voor marketeers die een product in de markt moeten zetten aangezien ze op die manier consumenten kunnen opdelen in verschillende segmenten en dan deze dan benaderen met een specifieke marketing campagne (Westad et al., 2003). Naast deze geanticiperde emoties zijn er ook emoties die ervaren worden tijdens en na consumptie. De resultaten van dit onderzoek bevestigden voorgaand onderzoek dat positieve emoties de acceptatie verhogen (Gibson, 2006, Desmet and Schifferstein, 2008). Dit wordt ook wel de 'hedonische asymmetrie' genoemd (Desmet and Schifferstein, 2008). Daarnaast is het zo dat verschillende sensorische profielen aanleiding geven tot verschillende emotionele profielen van producten. Deze emoties zullen eveneens een invloed hebben op de acceptatie van de chocolade producten. De studies in dit deel gaven ook aan dat geslacht en voorafgaande preferentie weinig of geen invloed hadden. Consumptie frequentie en gedrag bleken dan weer wel een significante impact te hebben op de emotionele profielen.

Het derde objectief is om na te gaan hoe sensorische analyse kan bijdragen tot nieuwe productontwikkeling. Dit deel geeft de mogelijkheden en toegevoegde waarde aan indien sensorische analyse wordt ingebouwd in twee methoden die beiden ideeën voor consument gedreven product ontwikkeling opleveren. QFD kan gebruikt worden als communicatie middel tussen verschillende departementen en opties kan aanleveren om productie aan te passen, zal conjoint analyse informatie geven omtrent mogelijke combinaties van attributen om een nieuw product samen te stellen en het op de meest geschikte manier te vermarkten. Wanneer een conjoint analyse wordt uitgevoerd voorafgaand aan QFD, kan de combinatie van de methoden tot nieuwe product ontwikkeling leiden aangezien de eerste methode informatie verschaft over de samenstelling van een product en het tweede bepaalt hoe dit product moet geproduceerd worden.

Finaal worden er enkele mogelijkheden voor verder onderzoek naar voor geschoven zoals (1) combinatie van sensorische analyse en flavour/aroma analyse om een praktische tool te ontwikkelen voor productevaluatie (2) onderzoek omtrent de kloof tussen de drempelwaarden voor detectie van verschillende attributen (3) ontwikkelen van een methode die simultaan sensorische eigenschappen en emoties kan meten (4) de nood aan een methodiek die nieuwe productontwikkeling bekijkt vanaf de start (idee genereren) over de productie tot de finale acceptatie van de consument.

Summary

In today's business, developing new products is a key objective for food companies. Mesias et al. (2013) stated that the current changes in social and consumption patterns give rise to new possibilities in food product development although there are also challenges that producers need to overcome. For the past decade, studies on new product development state that in the food industry this process needs to be consumer-driven (Linnemann et al., 2006, Van Trijp and Steenkamp, 1998, Craig and Hart, 1992). However, in order for consumer-driven food product development to be successful, one needs to understand the complexity of food perception and food preference by consumers (Linnemann et al., 2006, Sijtsema et al., 2002).

This doctoral research aims to identify opportunities how sensory analysis can play a part in this innovation process or at least serve as a tool to gather information for improving the features (marketing, product or process) of a product. This doctoral research is divided in three major part which focus on the sensory evaluation of chocolate products and how this can be interlinked with process parameters (Part I), emotions and consumer behaviour (Part II) and consumer-driven product development (part III) in order to increase the success of products.

This doctoral research uses both primary and secondary data sources. Primary data were collected through the use of qualitative, quantitative and experimental research procedures. Secondary data were used as input information for the qualitative research and to review the current use of sensory analysis in conjoint methodology.

Three main research objectives are distinguished, leading to six research questions. The first research objective was to identify the key sensory attributes for chocolate. This raises the first research question which sensory attributes are used by consumers to assess the quality of chocolate? Chapter 2 showed that it is important to look at different flavours but also to differentiate the intensities of texture characteristics. A next step is to study if sensory analysis can contribute to characterise physical product features. All studies conducted in Part I illustrate the complexity of chocolate products and the necessity of good understanding the sensory characteristics of chocolate and how they interact both with processing conditions and consumer acceptance. The complementarity of sensory and instrumental measurements can be of great value when trying to answer specific research questions.

The second research objective was to investigate the attitudes and emotions towards chocolate consumption. Since it is stated that the popularity of chocolate is related to the emotions it evokes with the consumer (Macht and Dettmer, 2006, Parker et al., 2006), this

part focuses on the anticipated and evoked emotions related to chocolate consumption. The results showed that anticipated emotions and emotional beliefs are closely related to the intention to consume and the actual behaviour of consumers towards chocolate consumption. The research also indicated that the Belgian and Hungarian consumers ground their consumption decision on different beliefs. Understanding the differences between these beliefs, is valuable information for the marketers that need to commercialise these products as this can help a company in the segmentation of consumers and target them with a specific marketing campaign (Westad et al., 2003). However, next to anticipated emotions, emotions are also evoked during and after consumption. The obtained results confirmed previous findings that positive emotions increase the acceptance of chocolate (Gibson, 2006, Desmet and Schifferstein, 2008) which is called the hedonic asymmetry (Desmet and Schifferstein, 2008). Moreover, it could be that differences in sensory profiles can result in different emotional profiles as perceived during and after consumption of chocolate and these emotions affect the acceptance of the products. In these studies gender and prior preference had little influence whereas consumption frequency and attitudes had a significant impact on emotional profiles.

The third research objective was to examine how sensory analysis can contribute to new product development. This part presented the possibilities and added value of incorporating sensory analysis in two methods that both present opportunities for consumer-driven product development. Whereas the QFD can be used as a communication tool over different departments and offers options to change the production, the conjoint analysis provides information on the possible combination of attributes to construct the product and market in the most appropriate way. If a conjoint analysis is conducted prior to QFD, the combination of the two methods can lead to new product development as the former gathers information on the composition of the product and the latter can define how this can be produced.

Finally, possibilities for future research are presented focusing on (1) combining sensory analysis and flavour/aroma analysis to develop a practical tool for product evaluation (2) research on the gap between thresholds for detection of certain attributes (3) development of methods to measure emotions and sensory analysis simultaneously and (4) the need for an overall method that looks at new product development from start (idea generating) over processing to final acceptance of the consumers.

Chapter 1

General introduction, objectives and outline of the research

Preface:

Part of this research has been performed in the framework of the European Union (EU) Seventh Framework Program Integrated Project ProPraline 'Structure and processing for high-quality chocolate pralines' (2008-2012). The objective of this project was to improve the competitiveness of the European SMEs producing exclusive, complicated and niche-oriented products like filled chocolates by developing knowledge and technical solutions to improve the quality and extend the shelf-life of their products. The project provided through SME associations demonstration and training to a large number of European SMEs in how to manufacture new innovative, high quality filled chocolates.

UGent SensoLab was responsible for the sensory analysis as part of the quality assessment of filled chocolates, taking into account the consumer perspective. Thus far, very few studies concerning fat bloom and cracking have concentrated on the alterations of sensory characteristics of filled chocolates. This is one of the gaps that were tackled in this project, at least partly. This doctoral thesis reports original results obtained from ProPraline and other research activities.

1.1. General introduction

This general introduction presents the rationale of the doctoral research and why the chocolate sector was chosen as research case. Next it includes the description of conceptual framework and the related research objectives and research questions. Further it describes the research gaps and scientific contribution of this research. Next, the research design and data sources are clarified together. Finally the structure of the thesis is presented.

1.1.1. Rationale of the doctoral dissertation

1.1.1.1. New product development: the need to innovate

In today's business, developing new products is a key objective for food companies. Mesias et al. (2013) stated that the current changes in social and consumption patterns give rise to new possibilities in food product development although there are also challenges that producers need to overcome. Although the food industry is traditionally known to be a sector with little innovation (Moskowitz and Hartmann, 2008), recent changes have forced the sector to innovate in order to stay in business (Sarkar and Costa, 2008). One of these changes is the consumers' demand for high quality food products, convenient to cook and eat (van der Valk and Wynstra, 2005). In 2013 and 2014, the main driver for innovation was increasing pleasure for the consumer followed by health and convenience (FoodDrinkEurope, 2015) (Figure 1. 1). Pleasure, including variety of senses and sophistication, is by far the leading axis with a 56% share in 2014.

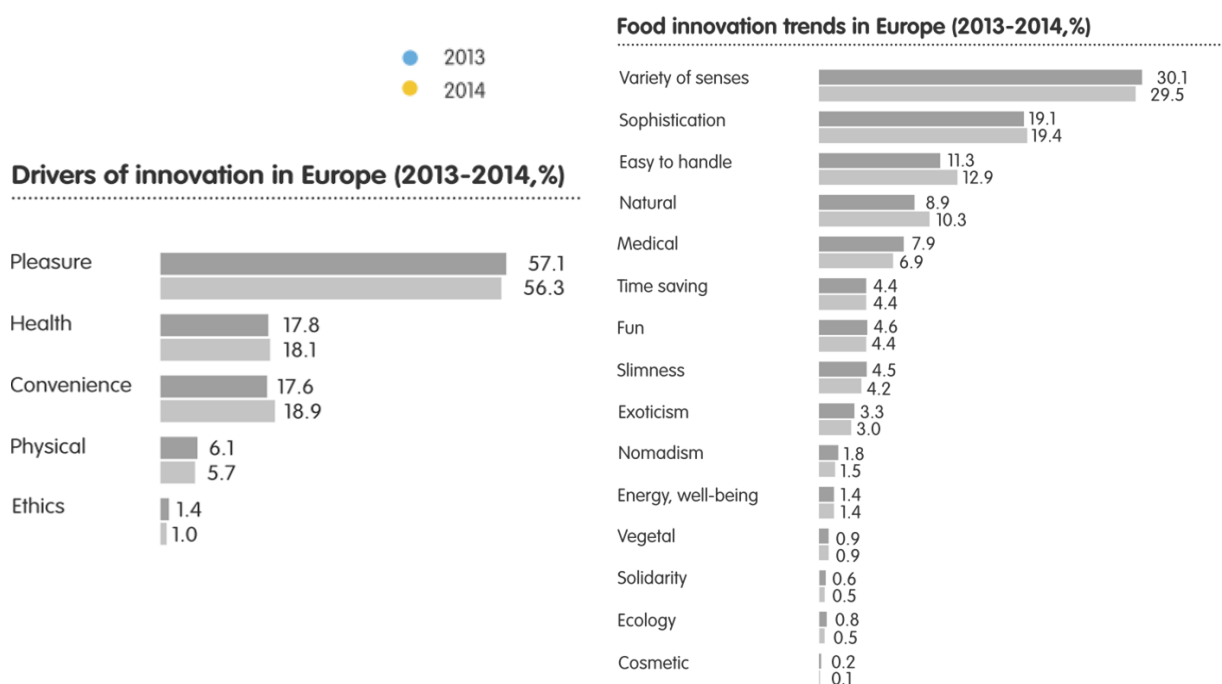


Figure 1. 1: Food innovation trends in Europe (2013-2014) (FoodDrinkEurope, 2015)

The product development process has been defined as a multi-step process which includes concept or idea generation, research and development, product testing and marketing launch activities (Stewart-Knox and Mitchell, 2003, Rudder et al., 2001). The first models that were developed for product development indicated that a stepwise approach would lead to higher success rates (Cooper and Kleinschmidt, 1987). Nowadays, most studies indicate that a development process which is flexible, overlapping and team oriented, is the way to go (Cooper and Kleinschmidt, 1996). The combination of an interdisciplinary team, an original product idea, a thorough market research and careful planning could inhibit the problems later on in the development process (Stewart-Knox and Mitchell, 2003). Several models indicated that the success of the development process is also related to activities such as consumer testing and the translation of consumer needs into details for technical development (Rudder et al., 2001).

For product innovations and reformulations to be successful, a company needs to understand the influencing factors in food choice. Moreover, they need to identify what their impact is on purchase decision (Solheim and Lawless, 1996), given that food products are becoming even more complex due to consumers' demands (Chamorro et al., 2015).

Accordingly, the current literature on innovation is filled with the recognition that the voice of the consumer must be taken into account and that the product development needs to be consumer-driven (Jaeger et al., 2003, Stewart-Knox and Mitchell, 2003) or user-oriented (Grunert et al., 2008). This type of product development is defined as *'the process towards the development of a new product or service in which an integrated analysis and understanding of the users' wants, needs and preference formation play a key role'* (Grunert et al., 2008). Although this element is critical in the innovation process, the producer must also think of availability of possible resources, technological capabilities and competitors (Moskowitz and Hartmann, 2008). Moreover, the literature on 'voice of the consumer' presents a contradicting image. Most of the research indicates that incorporating the consumer needs and wants is the only way to product innovation while other studies indicate that consumers do not know what they want (Moskowitz and Hartmann, 2008, Grunert et al., 2008). The literature has dealt with this problem by talking about latent needs which are needs that a consumer will become aware of when products fulfilling these needs are available on the market (Leonard and Rayport, 1997). However, this concept of latent needs has no theoretical foundation in the purchase behaviour literature.

Rudder et al. (2001) state that models of food product development should include the sensory characteristics of food products. At a time when new products have substantial failure rates, it is necessary to cultivate and refine every possibility that can lead to successful innovative food products. Moskowitz (1999) identified four opportunities to include sensory analysis in the product development process: (1) *Pre-work*: before concepts/ideas are created, the sensory attributes that drive acceptance or needs have to be identified (2) *Concept infancy*: identify sensory opportunities, the sensory "holes", in the food category that can be the basis of a product concept/idea (3) *Product to fit a concept*: create product formulations

that match concept or image profiles or (4) *Concept to fit a product*: actually create combinations of concept elements that fit a product or an end use. This doctoral research explores the possibilities of using sensory analysis in pre-work, concept infancy and concept to fit a product. During this research, no actual products were produced; therefore the option of 'product to fit a concept' was not studied.

A commonly used method in today's industry is the Stage-gate® Idea-to-Launch Process (Cooper, 2001). The Stage-gate® process is a map that moves a product idea to the actual launch of this product. It consists of a set of information-gathering stages followed by a go or kill decision gate (Cooper, 2008). As the criteria for each gate are predetermined, this gives a company an objective tool to effectively and efficiently go through the product development process. The work that needs to be done in every stage requires a cross-functional team. A traditional Stage-gate® process contains six stages: Discovery, Scoping, Build Business Case, Development, Testing and validation and Launch (Figure 1. 2). Each stage consists of specific activities and analyses that lead to predefined deliverables. These deliverables are input for the gates. At every gate, certain criteria need to be met and together with the information from the deliverables, the so-called gatekeepers can provide an output. This will be a decision to go/kill/hold/recycle, an action plan for the next stage and the approval to provide the necessary resources.

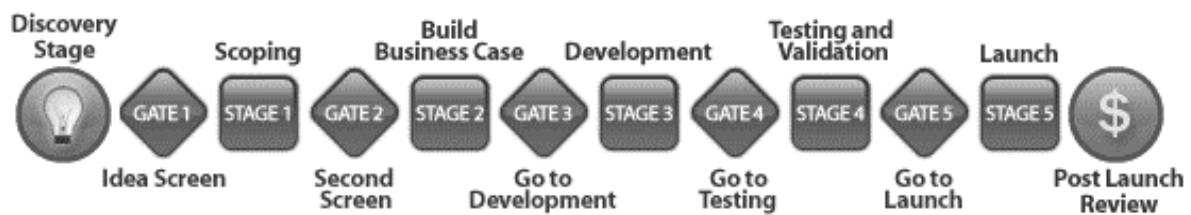


Figure 1. 2: The Stage-gate® Idea-to-Launch Process (Product Development Institute Inc, 2016)

Although Cooper (2008) indicated that some companies have a problem by demanding too many different tasks in every stage, sensory analysis is one aspect that should be implemented in the stages of the process when developing new food products.

Through sensory analyses, it is possible to construct a perceptual map of the sensory characteristics that lead to quality perception and associated preference (Grunert et al., 2008). The combination of descriptive sensory analysis with trained panels and affective sensory analysis with potential consumers can be particularly interesting to test the effectiveness of new products or product improvements. This allows the producer to target these sensory characteristics that need to be adjusted in order to obtain a higher degree of consumer acceptance (Muñoz, 2002). The incorporation of sensory analysis in consumer-driven product development could therefore provide fundamental and applicable insight in why a consumer prefers one product over another.

The descriptive sensory analysis is closely related to the technological aspects of food products (Costa et al., 2001) and both define the objective food quality of a product. This interrelation and methods to measure this interaction are studied in Part I of this doctoral

research. Part II focuses on the attitudes and emotions related to consumer behaviour. The purchase behaviour literature indicates that these are also important in new product development as they often influence quality perception (Ajzen and Fishbein, 1980). In Part III, the possibilities and drawbacks of incorporating sensory analysis in two frequently used methods for product development and product improvement are identified.

1.1.1.2. The need for sensory analysis in the food industry

Food is one of the basic human needs to survive and be healthy. However, it is also a substantial source of psychological satisfaction (Steenkamp, 1990). The sensory quality of food is an important parameter for marketers and product developers in the food industry in terms of designing, testing, launching, and rethinking food products. Sensory analysis collects empirical data that addresses how human sensory systems function from stimulation and perception to cognition and behaviour (Van Trijp and Steenkamp, 1998). Consequently, sensory analysis has developed remarkably in the past 60 years and has gained an increasing number of users in the food industry (Sidel and Stone, 1993).

The following parts give the definition of sensory analysis, present a short overview of possible problems when applying sensory analysis in the food industry and finally the importance of combining sensory analysis with marketing research.

Definition of sensory evaluation

The most frequently used definition of sensory evaluation is given by Stone and Sidel (2004c) and Dijksterhuis (1997):

'Sensory evaluation is a scientific discipline used to evoke, measure, analyse, and interpret reactions to the characteristics of products or materials as they are perceived by the senses of sight, smell, taste, touch and hearing'.

In the definition, we can extract four main points. First, *'to evoke'* which implies that in sensory analysis a stimulus (e.g. taste of food products, texture of personal care products, etc.) is presented to a respondent in such a way that this stimulus can be perceived. In order to minimize biasing factors, the experimental design is crucial as the evaluation needs to be based only on sensory properties (Lawless and Heymann, 2010).

The second point that needs to be considered is *'to measure'*. A test design does not only involve the selection of an appropriate test or respondents, but also the selection and use of the appropriate scale (Meilgaard et al., 2006). Numerous scales are developed in order to measure the response of trained panellists or consumers. Understanding the benefits and drawbacks of these scales is essential to set up a correct test design (Stone and Sidel, 2004b).

The third and for some sensory scientists the most critical process in sensory evaluation is the *'analysis'* of the data. As a result, a new field in sensory analysis was developed called *'Sensometrics'*. It is defined as the scientific area that applies mathematical and statistical methods to problems from sensory and consumer science (Tuorila and Monteleone, 2009).

The '*interpretation*' of results is the fourth aspect that needs to be considered. A sensory expert is trained to extract information from experimental data and statistical results in the context of hypotheses and research questions while taking into account background knowledge on the topic and possible implications (e.g. context effects) before coming to conclusions and deciding on follow-up actions (Lawless and Heymann, 2010).

Based on the reception of the five senses, the sensory attributes can be categorized in five groups: appearance, audition, texture, taste and smell. For every group, a definition is presented:

Appearance: Appearance relates to visual properties of a food, including size, shape, colour and uniformity. Appearance is an important aspect of food quality as it is the first subjective evaluation made of food quality. The product has to pass the visual assessment before the consumer can or will consider the other parameters such as taste and texture.

Sound: Hearing is the physiological process of perceiving sound. It might sound strange in the context of eating food, but we register the sound of chewing, which can be an important aspect of our reaction to a product. However, in this dissertation, the sensory attributes related to hearing are not further analysed.

Texture: Texture relates to the reaction of food to stress. The movement of the jaw during biting and chewing or the movement of the tongue during chewing may introduce this stress. Texture usually relates to solid food while viscosity relates to homogeneous liquid foods and consistency relates to non-homogeneous liquid foods. Instrumental methods only measure one aspect of "texture" and again cannot relate the complex interactions which produce the perception of food texture.

Taste: Organoleptic attribute perceptible by the taste organ when stimulated by certain soluble substances. Five basic tastes are already clearly defined: salt, sweet, bitter, sour and umami. Sensory scientists are currently discussing on a sixth taste: fat. A basic taste is one for which specific taste buds have been identified as being physiologically responsible for the particular taste sensation.

Aroma: Organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances. The human nose is capable of detecting thousands of different odour substances. However, our sensitivity is much less than other animals (animals use smell for food, mating, territory etc).

Next to these five groups, the term '**flavour**' is frequently used in sensory evaluation. Flavour is defined as a complex sensation coming from a combination of the olfactory and gustatory attributes perceived during tasting, which may be influenced by tactile, thermal, painful and even kinaesthetic effects. What is commonly referred to as taste/flavour is actually a combination of taste, smell, touch and temperature. Sensory assessment of flavour is usually done in three separate stages of perception:

1. Odour assessment – this involves sniffing the food before it enters the mouth

2. Flavour-in-mouth assessment – this involves taking the food into the mouth and assessing a combination of sensations included in the above definition
3. After-taste assessment – this involves the sensation perceived during a specified period after the sample has been swallowed or rinsed from the mouth

Given that many instruments used in instrumental analysis, are not as sensitive as the human sensory system (Meilgaard et al., 2006), sensory analysis creates a better understanding of how the five senses (sight, smell, hearing, taste and touch) react during food intake (Bech et al., 1994). It has the ability to predict how humans respond to foods ingredients, processing, packaging, and shelf life. Practically, sensory analysis provides information that is useful for management decisions regarding product development and product improvement. Given the information gained from sensory analysis, these decisions can be made with lower uncertainty and risk. Sensory analysis also functions for other purposes, for instance in quality control (QC) or quality assurance (QA) (Muñoz, 2002). It may help to understand the attributes of a product that consumers belief to be important for product acceptance (Cavicchi et al., 2010).

Grasping the thoughts of a consumer during tasting or consuming a product helps to understand and interpret the sensory evaluation data (Wansink, 2003). Moreover, these thoughts also provide information on how the sensory features are going to influence attitudes and consumption behaviour. The overall results can provide suggestions on how to modify the product to get wider acceptance in the market. Besides that, research indicated that repeated purchase is primarily driven by sensory quality (Haddad et al., 2007, Grunert, 1997).

Problems with application of sensory analysis in the food industry

Moskowitz and Hartmann (2008) state that in its development sensory analysis developed in the direction of 'profiling' of products with expert panels who were extensively trained which resulted in 'sensory fingerprints'. These fingerprints are defined as the characterisation of the sensory profile (Lawless and Heymann, 2010). The possible combination with psychophysics which deals with how sensory systems transform a physical stimuli and mixtures of these stimuli in responses, was left unexplored. Consequently, as the producers do not understand or know what to do with these sensory profiles, these profiles are not leading to concrete actions necessary to alter a product. The sensory analysts should provide actionable information that goes beyond the traditional sensory description of products. By combining different tools, this doctoral research aims to identify opportunities for product development or improvement and possibly define when sensory tests are useful in the product development process.

The most quoted criticism on sensory analysis over the past decades is the difficulty in translating the results to marketing or sales departments (Simeone and Marotta, 2010). Frequently, the answers that sensory analysts provide do not match the questions identified

by marketers, and vice versa. The quantity of statistics on one side and the quota for sales on the other has resulted in a lack of understanding between the two disciplines. Interestingly, this area has been identified by several authors as potentially the most profitable opportunity for innovation in the food industry (Moskowitz et al., 2006, Moskowitz and Hartmann, 2008).

The cross-over between different departments or disciplines is what will drive innovation in a food company. In order to develop new or improved products, collaboration between R&D, the sensory and the marketing departments is necessary (Van Kleef et al., 2002, Moskowitz and Hartmann, 2008). However, these functional teams are traditionally situated in different parts of the company, often with limited or uncoordinated communication among them (Bech et al., 1994). This shortcoming slows down or even completely blocks new product development or product improvement.

Importance of combining sensory analysis in food marketing research

In practice, sensory analysis is commonly combined with market research; however there are several significant differences between those two methods. Sensory analysis is related to intrinsic quality cues of a product whereas market research is related to extrinsic product quality cues (Deliza and MacFie, 1996). In sensory tests, samples are coded so that the product identities are usually hidden and minimal information is given (Stone and Sidel, 2004c). Potentially biasing factors such as label claims, image of advertisement, or nutritional facts are eliminated in order to assure that the collected data is based on sensory characteristics only. Conversely, market research is conducted with branded products and brings the concept of the product directly to the participants. A high number of potential response biases exist as participants want to satisfy the researcher and give results harmonious with what the researcher expects or what is socially accepted (Almli et al., 2015). In case of creating improvement strategies of product failures, information on intrinsic and extrinsic attributes is necessary. Sometimes conflicting results are obtained as a result of different styles of sensory tests and market research tests. However, it does not imply that one of them is right and the other is wrong (Lawless and Heymann, 2010).

In conclusion, an integrated approach is necessary to study all these aspects to get a better understanding of consumers' preference (Grunert et al., 2008). To achieve this, experts from different disciplines need to collaborate to develop an experimental design which approaches real life situations without allowing more bias in the experiment.

For the past decades, studies on new product development state that in the food industry product development needs to be consumer-driven (Linnemann et al., 2006, Van Trijp and Steenkamp, 1998, Craig and Hart, 1992). However, in order for consumer-driven food product development to be successful, one needs to understand the complexity of consumers' food perception and food preference (Linnemann et al., 2006, Sijtsma et al., 2002). This perception is driven by the personal characteristics, the food characteristics, the context and influence of family and friends.

In this doctoral research, the focus will be on product and individual characteristics whereas the context and environment will not be taken into account. A first part will focus on the product, a second on the individual whereas the third part will integrate these two aspects in methods that can be used in new product development. Finally, it will also identify opportunities on how sensory analysis can play a part in new product development or at least serve as a tool to gather information for improving the features (marketing, product or process) of a product.

It must be noted that price is not taken into account in this research. Enneking et al. (2007) argued that a simultaneous evaluation of intrinsic and extrinsic product attributes is demanding for the respondent and thus difficult to match with pricing research. Moreover Erickson and Johansson (1985) indicated that price could have a dual role. On the one hand, it could have a positive effect on attitude while on the other have a negative effect on intention to buy. For example, when a product has a higher price, the consumer might perceive it as a higher quality product. This higher price could however prevent the consumer from buying the product. This duality should be kept in mind when conducting consumer studies. For these reasons, the researchers therefore decided not to incorporate price as an attribute in the consumer studies conducted here although that for actual product development, this is a factor that needs to be taken into account in all steps.

In conclusion, this research focuses on the sensory evaluation of chocolate products (Part 1.1.2) and how this can be interlinked with process parameters, consumer behaviour and consumer-driven product development in order to increase the success of products.

1.1.2. The chocolate sector as research case

This doctoral research focuses on the chocolate sector. Chocolate is a semi-solid suspension of approximately 70% fine solid particles from sugar and cocoa (and milk powder depending of the type) in a continuous fat phase (Afoakwa, 2010, De Clercq, 2011).

The Codex Alimentarius defined some specific characteristics for dark, milk and white chocolate (Codex Alimentarius Commission, 1981):

Dark chocolate needs to contain:

- not less than 35% total cocoa solids (a dry matter basis)
- minimally 18% cocoa butter
- minimally 14% fat-free cocoa solids

Milk chocolate needs to contain:

- not less than 25% total cocoa solids (a dry matter basis), including a minimum of 2.5% fat-free cocoa solids
- a specified minimum of milk solids between 12% and 14% (including a minimum of milk fat between 2.5% and 3.5%)

White chocolate needs to contain:

- not less than 20% total cocoa butter (a dry matter basis)
- not less than 14% milk solids (including a minimum milk fat in a range of 2.5% to 3.5%)

In this dissertation experiments with both dark chocolate and milk chocolates are conducted. However, some studies also use filled chocolates which is defined as '*a product covered by a coating of chocolate, the centre of which is clearly distinct through its composition, from the external coating. The chocolate part of the coating must make up at least 25% of the total weight of the product concerned*' (Codex Alimentarius Commission, 1981).

Chocolate is known to be a product which is specifically consumed for the sensory arousal it gives to the consumer through aroma, taste and melting behaviour (Mela, 2000, Parker et al., 2006). Next to the unique and attractive taste (Parker et al., 2006), the popularity of chocolate is known to depend on the emotions that chocolate consumption evokes (Macht and Dettmer, 2006, Parker et al., 2006). Some authors even defined chocolate as a comfort food which is a food product whose consumption evokes a psychologically comfortable and pleasurable state of mind (Wansink et al., 2003, Anonymous, 1975). Chocolate is an interesting product to study in the frame of sensory analysis as it has very specific sensory characteristics which are closely linked to the complexity of the processing. Moreover, the subjective evaluation of chocolate products is always a combination of sensory preference, consumer attitudes and beliefs and extrinsic characteristics such as brand and price.

In 2014, the chocolate product sector ranked ninth in the top 15 of most innovative sectors in the food industry (FoodDrinkEurope, 2015)(Figure 1. 3). However, the chocolate industry is facing some challenges as consumption in developed countries is stalling (Skelly, 2015). Reasons for this drawback are the already high consumption levels, the increasing health awareness of consumers and the existence of more snack alternatives. Two options are available to tackle this problem, either expanding to developing markets or adding more value to the products available in developed markets. In the latter option, new product development with focus on premium quality products and attention for the consumers' needs is recommended as a solution (Skelly, 2015). Some of these identified needs are variety in flavour, preference for dark chocolate, portion size control and origin (Tholen, 2015).

Sensory analysis can play an important part in meeting these needs (Christy, 2015). Many researchers have already studied the sensory characteristics of chocolate and confectionary products (Thomson et al., 2010, Sune et al., Popov-Raljić and Lalicic-Petronijević, 2009, Jovanović and Pajin, 2002, Januszewska and Viaene, 2001b, de Melo et al., 2009, Thamke et al., 2009). Next to that, the physical characteristics and attitudes towards chocolate have also been studied extensively (Thomson et al., 2010, Rozin et al., 1991, Parker et al., 2006, Macht and Dettmer, 2006, Depypere et al., 2009b, Depypere et al., 2009a, De Graef et al., 2005, Benton et al., 1998, Afoakwa et al., 2008b, Afoakwa et al., 2008c, Afoakwa, 2010).

This doctoral research combines research on interaction between sensory characteristics on the one hand and instrumental analysis or emotional evaluations and consumer behaviour on the other hand. Moreover, it combines these elements in methods that generate possibilities for product development. This makes chocolate products and possible application in the chocolate industry an ideal study subject for this doctoral research.

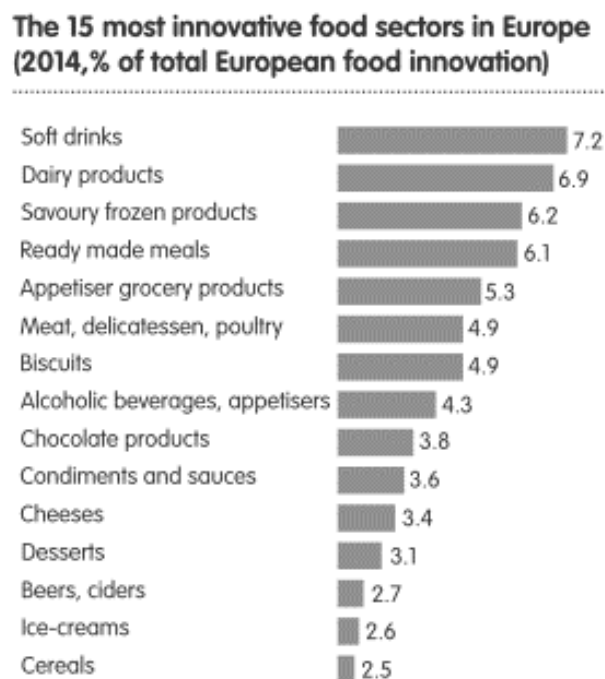


Figure 1. 3: The 15 most innovative food sectors in Europe (2014, % of total European food innovation)(FoodDrinkEurope, 2015)

1.1.2.1. *Chocolate confectionary production*

Cocoa is one of the most important cultivated crops worldwide both in production and processing. The largest cocoa production plants are situated in Africa (72.6%), followed by America (17.8%) and Asia & Oceania (9.6%) in 2014/15. These continents have the ideal climate for the growth of the *Theobroma Cacao L.* The processing is primarily done in Europe (37.9%) and United States of America (21.1%) followed by Asia & Oceania (20.9%) and Africa (20.1%) (International Cocoa Organization, 2015b). The total production has increased by 3.9 million tons in 2012/13 to 4.2 million tons in 2014/15 (International Cocoa Organization, 2015b). Switzerland has the highest per capita consumption worldwide with 8.98 kg, followed by Germany (7.89 kg), Ireland and UK (both 7.39%), Norway (6.62 kg) and Austria (8.2 kg) (Statista, 2016). Statista (2016) indicates that in 2015 India's chocolate confectionery consumption will increase 127.6%, followed by Poland (60.8%), Argentina (47.9%), Turkey (47.5%) and China (46.4%). Forecast of the leading chocolate consuming countries in 2020 indicates that the second ranked country for chocolate consumption in 2020 will be Russia, making up 11% of the global consumption. The US will be the largest consuming country in share of global consumption.

Food and Drink Europe indicates that the chocolate and confectionary sector belongs to the top three export sectors (+9%) and also to the top three import sectors (+17%) (FoodDrinkEurope, 2015). Moreover, the Economic Bulletin Q3 2015 of Food Drink Europe indicated that the export grew with 19.7% compared to Q3 2014. Belgium ranks second on the list of exporting countries in dollar value (\$3 billion) and accounts for 10.7% of the total chocolate exports by country (Workman, 2015). Moreover, Belgium also ranks second in top positive net exports for chocolate during 2014 (\$2.2 billion) (Workman, 2015).

Euromonitor predicted that in 2014 the revenues of the chocolate industry would rise with 6% (KPMG, 2014). This is driven by the increasing demand in emerging markets and recovery of the US market (KPMG, 2014). Another report indicates that for cocoa the market size (volume) of cocoa was 3,455,622 metric tons in 2013 and is estimated to grow at a compounded annual growth rate (CAGR) of 3.1% from 2014 to 2019 (MarketsandMarkets, 2014). As for the chocolate market, it's projected to grow at a CAGR of 2.3% from 2014 to 2019. So, by 2019, the world cocoa market is expected be worth about \$2.1 billion, and the world chocolate market is expected to be worth about \$131.7 billion (MarketsandMarkets, 2014).

Nowadays, the change in weather patterns is increasingly affecting the cocoa trees. Periods of drought and of excessive rain due to climate changes can have a negative impact on the growth of cocoa. However, there is a stable demand growth due to the increasing discretionary income of the middle class in developing countries such as China, India and Brazil. The combination of these changes in supply and demand is putting an upward pressure on cocoa and chocolate prices (World Cocoa Foundation, 2014). The ICCO

(International Cocoa Organisation) Daily Price¹ first closed above \$3,000 per metric ton on February 12, 2014. In December 2015, the ICCO daily price averaged US\$3,346 per ton. End of 2015, the London and New York markets recorded increases over the previous year, of 15% and 11% respectively (International Cocoa Organization, 2015a).

Given that prices are increasing, chocolate producers are always looking for ways to make a product that meets the needs and desires of consumers and to produce as efficiently as possible. Therefore, they are using different cocoa bean varieties, changing the production process or searching for alternatives for the necessary ingredients (Afoakwa, 2010). These alterations have an effect on the physicochemical, functional and sensory characteristics of chocolate (Afoakwa et al., 2007). However, consumers evaluate the quality of chocolate on appearance, aroma, texture and taste but also on the flavour of the chocolate. Consequently, it is important to understand the key sensory attributes that drive consumers. These parameters should be taken into account when producing chocolate.

1.1.2.2. Influencing factors in the formation of chocolate sensory characteristics

Development of sensory characteristics during production

The use of different cocoa bean varieties results in different flavour profiles of the chocolates. These differences are due to the composition of the cocoa beans, the botanical origin, the growth location and agricultural circumstances (Afoakwa, 2010). Every bean variety has a unique flavour potential but the growth conditions such as climate, amount of sunlight and rain, characteristics of the soil, time of harvest and time between harvest and fermentation allow variations in the final flavour development. The differences in flavour profiles of these bean varieties can be determined after roasting at standard conditions (Nuttall and Hart, 1999).

The flavour development is depending on the composition of the cotyledons but also the post-harvest processing has a high impact. This processing also affects the texture and the appearance of the chocolate (Afoakwa, 2010). Many researchers have studied the precursors for flavour formation in cocoa and chocolate (Counet et al., 2004, Afoakwa et al., 2009a, Afoakwa et al., 2008a). In summary, the characteristic flavour and aroma of the chocolate originates from two types of parenchyma storage cells in the cotyledons (Osman et al., 2004). Polyphenolic cells contain the polyphenols and alkaloids (caffeine, theobromine and theophylline). High concentrations of polyphenols will lead to astringent flavour in chocolate whereas the alkaloids contribute to bitterness. The lipid protein cells contain proteins, lipids and starch, which all play a role in the cocoa flavour and aroma (Afoakwa et al., 2008a, Kim and Keeney, 1984).

¹ The ICCO Daily Price is the average daily closing price of the three nearest delivery date contracts trading on that day.

Fermentation is essential for the development of the flavour profile as the flavour precursors are formed in this stage of processing. Further, it influences the colour development and reduces the bitterness. The cocoa beans are transferred to heaps which cause the temperature to rise. This creates ideal conditions for the production of acetic acid by micro-organisms that decreases the pH. Due to this environment, a variety of enzymatic reactions will take place leading to the degradation of proteins and contribute to the formation of the flavour precursors (Lopez and Quesnel, 1973). One of the main effects of fermentation and conversion of the polyphenols is the decrease in astringent flavour. This polyphenol oxidation also induces the typical brown colour formation. When fermentation is not correctly carried out, off-flavours are formed. A well-known example is the 'hammy' off-flavour which is correlated to over-fermentation (Afoakwa et al., 2008a).

After fermentation, the beans need to be dried. During drying, the development of the brown colour and the flavours from cocoa bean precursors continues. A known problem in drying is the case-hardening which inhibits the decline of volatile acids which in turn has a negative effect on the final chocolate flavour. Brown colour, low astringency and bitterness and the absence of off-flavours and smoky aromas are indications of a good drying process (Awua, 2002).

During roasting of the whole bean, the shell loosens and is then removed in winnowing. The volatile acids are further removed. The classic chocolate and nutty flavours are a result of the Maillard reaction that takes place during roasting (Afoakwa et al., 2007, Fowler, 1999). Caramel flavour is also often associated with the Maillard reaction (Awua, 2002).

The soft chocolate taste is developed during grinding. The nibs of the cocoa beans are grinded to a particle size below 30 μm which is set as a standard value for particle size. Controlling the particle size distribution is necessary to get a soft and smooth mouth feel and avoid a grainy mouth feel (Beckett, 2009, Beckett, 2000).

The next step in the processing of the beans is conching. This is a crucial step for the development of the viscosity, final texture and flavour of the chocolate. Due to the high temperature, the residual volatile acids and moisture will be removed. Generally conching is a two-step process. In the first step, the powder or flakes are converted to a paste in which volatile acids and moisture are removed and the lipids are distributed through a continuous phase (Afoakwa et al., 2007). The second stage transforms this paste into a free flowing liquid by adding lecithin and cocoa butter. Conching improves the interaction between the solid particles and the continuous phase. This interaction determines the viscosity and the flow properties of the chocolate. The duration of conching defines the creaminess of the chocolate. In order to get the correct viscosity lecithin is added at the end of the conching step. It is also possible to add extra cocoa butter or a cocoa butter equivalent (CBE) before starting the tempering step (Beckett, 2000, Afoakwa, 2010, Awua, 2002).

Well-tempered chocolate has a good texture, shape, colour, gloss and contraction. It also prolongs the storage capacity of the chocolate (Depypere et al., 2009a). Poor tempering

leads to unwanted crystallisation of the cocoa butter and reduces the sensory quality of chocolate. Well-tempered chocolate crystallizes in the β_v form, which results in ideal sensory characteristics (De Clercq, 2011).

Influence of storage

Obviously, storage also affects the sensory characteristics of chocolate. The quality of the appearance and the taste will decrease during shelf life. To prevent this from happening, controlling the storage temperature is very important as chocolate is very sensitive for temperature fluctuations and heat. Temperature fluctuations and storage time will induce a recrystallization of the β_v crystals in β_{vi} crystals and cause fat bloom formation (Beckett, 2009). Furthermore, the humidity in the storage environment cannot be too high because this can initiate the development of sugar bloom. Air and light causes decomposition of the fats in the chocolate. The oxidation process causes a change of taste and the development of an unpleasant smell. As most fats, cocoa butter absorbs strong aromas, therefore it is advisable to store chocolate separate from products with a strong smell (Lonchamp and Hartel, 2004).

Influence of ingredients

Finally, the sensory characteristics of chocolate are also depending on the used ingredients next to the cocoa beans.

Cocoa mass or cocoa liquor is produced by grinding the nib of the cocoa bean. The quality of the cocoa liquor will depend on the beans used. Manufacturers often blend different types of beans to gain the required quality, flavour and taste (Beckett, 2009).

Cocoa powder is formed from the cocoa mass. Presses are used to remove some of the fat and leave a solid material called cocoa press cake. These cakes are then crushed to form cocoa powder. The processing can be altered to produce cocoa powders of different composition and with different levels of fat (www.icco.org).

Cocoa butter is solid at room temperature (20°C – 25°C) and melts to a liquid phase at body temperature (37°C). When residual solid fat is present at body temperature, this causes a unwanted waxy mouth feel (Torbica et al., 2006). Traditionally, the melting of the chocolate is steep which causes the flavour to be released in a short period on time increasing the intensity of the flavour (De Clercq, 2011).

Cocoa has a natural bitter taste which is produced by the presence of polyphenols and alkaloids. In order to prevent the chocolate of being too bitter, sugar is added. A change of 5% in the amount of sugar added has an effect on the flavour. Sucrose is mostly used in chocolate confectionary, while lactose is used in milk chocolate (Beckett, 2009). The size of the sugar particles is again crucial for a smooth mouth feel. Therefore it is important to control the sugar particle size distribution during grinding and refining (Afoakwa, 2010). In the production of milk chocolate, milk powder needs to be added. This contains milk fat which softens the chocolate. Milk fat is not sensitive to oxidation and influences the shelf life of the chocolate (Beckett, 2000, German and Dillard, 1998). Part of the cocoa particles will be

coated by the cocoa butter. However, surfactants such as lecithin are added to the chocolate to get proper viscosity and flow characteristics (Afoakwa, 2010).

The described interaction between production, storage and ingredients on the one hand and sensory characteristics on the other proves that chocolate is a complex product but that is what makes it a fascinating food product to study.

1.2. Conceptual framework

The conceptual framework of this doctoral dissertation (Figure 1. 4) is based on the new product design process (Van Trijp and Steenkamp, 1998), the total food quality model (TFQM) (Grunert, 1997), the quality perception process (Steenkamp, 1990), the extended quality guidance model (Van Trijp and Steenkamp, 1998) and the theory of planned behaviour (TPB) (Ajzen, 1991). These models are frequently used in research on consumer's quality perception or consumer behaviour studies. According to the concept of Quality Function Deployment (QFD), which is a general method for product development (Benner et al., 2003b) and also included in the conceptual framework (Figure 1. 4), the outcome of these research studies serve as input information for new product development or product improvement.

1.2.1. New product development or product improvement: voice of the company versus voice of the consumer

Developing products is a balancing exercise between "the voice of the company" and "the voice of the customer" (Van Trijp and Steenkamp, 1998). The ***voice of the company*** encompasses the managerial part in which decisions regarding the market, the refinement of the product through marketing, R&D, engineering and production or evaluations of the business opportunity need to be made (Craig and Hart, 1992). The concept of the Quality Function Deployment states that these managerial decisions need to be based on input from the customer part referred to as '*the voice of the customer*'. In the food industry and more specifically within this doctoral research the chocolate industry, which is a business to consumer environment, this is translated to '***the voice of the consumer***'. Understanding the needs and desires of consumers and exposing them to concept products or prototypes makes it possible to assess the market potential of a product. The Quality Function Deployment concept is defined as a method to structure product planning and development and thus as a method to indicate the interrelations between the voice of the company and voice of the consumer (Hauser and Clausing, 1988). It enables a company to specify the consumer's demands and needs, and to evaluate the proposed product systematically in order to determine its impact on meeting these needs (Benner et al., 2003b).

These needs and desires are driven by physiological and psychological processes (Ajzen, 1991). The physiological aspects are related to the product quality whereas the psychological aspects are related to personality characteristics. When defining physiological aspects of food quality, a distinction needs to be made between objective food quality and subjective food quality (Oude Ophuis and Van Trijp, 1995) as presented in Figure 1. 4. The psychological aspects encompass the beliefs and attitudes that drives consumers towards a specific behaviour. Sensory evaluation of food products has an influence on both physiological and psychological aspects as will be discussed below.

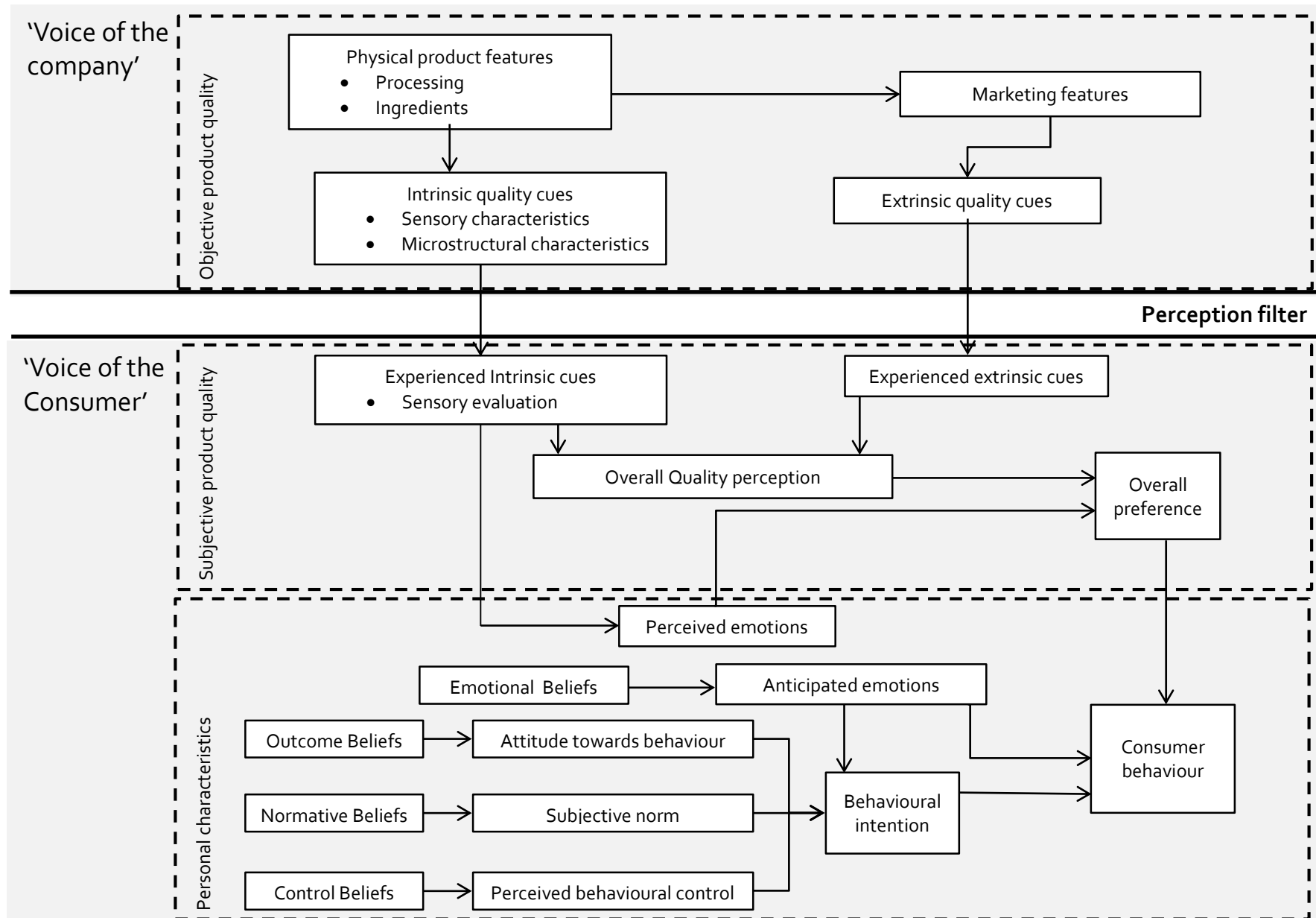


Figure 1. 4: Conceptual framework (Van Trijp and Steenkamp, 1998, Grunert, 1997, Steenkamp, 1990, Ajzen, 1991, Benner et al., 2003a)

1.2.2. Voice of the company: Objective product quality

Objective food quality covers product features which can be measured and verified. These features are decided on by the company and encompass **physical product features** (e.g. processing parameters or ingredients) but also the marketing characteristics (e.g. brand). These physical product features define the **intrinsic quality cues** but also serve as input information for possible **marketing features** (Van Trijp and Steenkamp, 1998). These marketing features cover the **extrinsic quality cues** of a product (Van Trijp and Steenkamp, 1998). The distinction between intrinsic and extrinsic attributes was made by Olsen and Jacoby (1972, Steenkamp, 1990). Intrinsic attributes refer to the physical characteristics of a food product which are quality cues that are inherent for a product such as the sensory and microstructural characteristics. Extrinsic attributes relate to aspects of the product which are not physically part of this product such as brand, price or production information.

Sensory analysis with trained panel and instrumental analysis serve as the objective measurement tools for respectively the sensory characteristics and the microstructural characteristics of food products (Meilgaard et al., 2006). The sensory dimension covers the appearance, taste, aroma and texture of food products whereas the microstructural dimension covers the ingredients and process by which the product is made (De Pelsmaeker et al., 2015). The extrinsic attributes are studied together with the intrinsic attributes in order to identify the influence of both and the trade-off between both on consumers' choice (De Pelsmaeker et al., 2013a).

All these objective food quality cues are decided on by the company when developing new products (Urban and Hauser, 1993, Van Trijp and Steenkamp, 1998). This dissertation focuses on how these intrinsic attributes can be defined most efficiently and which attributes, intrinsic or extrinsic, attributes have a decisive influence on consumers' food choice.

1.2.3. Voice of the consumer

1.2.3.1. Subjective product quality

Subjective food quality presents how consumers perceive food quality which can differ significantly from the objective food quality (Grunert, 2005). During the development or improvement of a product, a company tries to define the optimum mix of intrinsic and extrinsic attributes (Deliza and MacFie, 1996). However, the so-called **perception filter** influences the quality perception and experience of consumers (Risvik, 2001). This perception gap explains the difference between the objective food quality as designed by a company and the subjective quality as perceived and experienced by the consumer.

In the total food quality model, a distinction is made between perceived, expected and **experienced quality cues** (Grunert, 1997). These cues influence the consumers in their final choice which starts with the perception of the product. Based on this perception, consumers

create an expectation of these quality cues. When they actually consume the product, this expectation can be confirmed or disconfirmed which in turn leads to an experienced quality.

As this doctoral research focuses on sensory analysis of products, the experienced intrinsic and extrinsic quality is studied by conducting sensory consumer tests in which consumers indicate their preference and evaluate certain sensory attributes on a validated scale. These experiences then lead to an **overall quality food perception** of that specific product (Van Trijp and Steenkamp, 1998). This final overall quality perception results in an **overall preference** which leads to consumer behaviour (Costa, 2003).

1.2.3.2. *Personal characteristics*

The overall preference is however not only influenced by the overall quality perception but also by **personal characteristics** such as anticipated emotions, perceived emotions during consumption and attitudes towards a product. Consumer behaviour is influenced by more than only quality perception and experience from consumers. Ajzen (1991, 1985) designed a theory to predict and explain human behaviour in specific contexts, the so-called theory of planned behaviour (TPB). This theory states that **intention** leads to **behaviour** and that this intention is led by attitudes, subjective norms and perceived behaviour control. **Attitudes** are evaluative reactions to performing instrumental actions and are thought to be motivating the consumer to respond in a negative or positive manner to a certain action. **Subjective norm** captures the interpersonal aspects of behaviour which are largely based on the need of approval. **Perceived behavioural control** reflects the consumers' sense of control over a specific action. These three components are driven by salient **beliefs** related to these three major constructs (Ajzen, 1991).

This model has been extensively used to predict behavioural intention and consumer behaviour in food studies (Vermeir and Verbeke, 2008, Blanchard et al., 2009a, De Bruijn, 2010, Zhang et al., 2009). However, it is known that the food buying process is a routine process (Vanhonacker, 2010). Daily consumption is associated with a direct needs satisfaction and are likely to be resistant to change (Vermeir and Verbeke, 2008). Moreover, literature stated that an important shortcoming of TPB is its exclusion of affective processes, which are crucial for the intentional process (Van der Pligt et al., 1997). Such anticipated affective processes might be significant determinants of attitudes and intention to perform or not perform a behaviour (Van der Pligt and De Vries, 1998), especially in situations where the consequences of the behaviour are unpleasant or believed to be negative. An example is that when an individual anticipates feeling regret after performing behaviour, he or she will be unlikely to perform the behaviour. Simonson (1992) confirmed the effects of anticipated affective reactions on consumer behaviour.

Since chocolate is one of the most popular examples of foods which are consumed during comfort eating (Paoletti et al., 2012, Wansink et al., 2003, Anonymous, 1975), this research aimed to verify if the theory of planned behaviour can explain the behaviour of eating chocolate. Moreover, the theory was extended with the component '**anticipated emotions**'

to study how this influences the behaviour (Macht and Dettmer, 2006). Although there is evidence supporting the inclusion of anticipated affective reactions in the TPB for some behaviour, there is a variation in the way this is operationalized. Mohiyeddini et al. (2009) argued that although the affective beliefs are mostly presented in the TPB as a precursor for attitude, this position makes it difficult to measure the impact on attitude (Dillon and Kumar, 1985).

Other studies used anticipated emotions as a precursor for intentions stating that it transforms the motivational content to act given by attitude, subjective norm and perceived behavioural control into intention (Perugini and Bagozzi, 2001, Carrus, 2008). Therefore, anticipated emotions are added as a separate component of the TPB in this conceptual framework. However, the role of anticipated emotions is not limited to input for behavioural intention and consumer behaviour. This is discussed in the following part.

1.2.4. Interaction between subjective product quality and personal characteristics

A key component in this doctoral research is the influence of sensory characteristics and the evaluation of these characteristics by consumers which leads to an overall quality perception and to consumer behaviour. Although numerous studies have measured acceptance (liking) as the main driver for preference and food choice (de Graaf et al., 2005, Drewnowski, 1997, Helleman and Tuorila, 1991, Hetherington and Macdiarmid, 1995), recent studies show that understanding consumers' emotional responses to food additional to liking, can give new information to product developers (Cardello et al., 2012, Thomson et al., 2010, King et al., 2010, Gutjar et al., 2015).

The anticipated emotions as defined in the conceptual framework are influenced by how the sensory characteristics of food products are perceived and experienced by consumers. Moreover, the anticipated emotions that result from this sensory experience also drive the overall preference or liking.

Next to anticipated emotions, emotions are also evoked during or after consumption of food products. Based on these emotions, emotional profiles can be constructed for food products (King et al., 2010). Gutjar et al. (2015) states that emotional profiles provide new information that was not captured by measuring liking and that these profiles show differences between subcategories of products. King and Meiselman (2010) indicated that similar acceptability rating does not always correlate with similar emotion rating. Several studies showed that emotional profiles can be used to make distinctions between different products instead of using only liking scores (Cardello et al., 2012, Ng et al., 2013a, Spinelli et al., 2014a). Moreover, it was identified that emotional profiles can help in predicting food choice together with liking (Dalenberg et al., 2014, Gutjar et al., 2015).

1.3. *Structure of the thesis*

This doctoral research is a compilation of papers that have been published, accepted or submitted as contributions to international peer-reviewed journals, cross-covering the scientific disciplines of sensory analysis, food science & technology, consumer behaviour and marketing applications. Figure 1. 5 gives an overview of the different parts of this thesis and its related chapters.

Part I compiles research papers that fit with the first two research objectives. Chapter 2 aims to identify the most important sensory characteristics in consumers' choice when choosing chocolate. This results in the development of a sensory wheel assembling these key characteristics. In chapter 3, the correlation between sensory analysis and instrumental analysis is studied in three different studies. Together these studies indicate how sensory analysis can contribute in product and process development or improvement in order to stimulate innovation in food companies. In this part, the focus is on the sensory characteristics of chocolate and how important these characteristics are for production and consumer.

Part II investigates the drivers for chocolate consumption with a focus on the role of emotions. The research conducted in chapter 4 aims to gain more knowledge on how anticipated emotions play a part in this behaviour and the interaction of these anticipated emotions with other beliefs. To identify how anticipated emotions influence behavioural intention and behaviour of consumers towards eating chocolate, the theory of planned behaviour (TPB) was incorporated in the consumer study and extended with anticipated emotions. Based on the results of this research a study was set up to study which emotions are important when consuming chocolate. Therefore, the consumer sensory study in chapter 5 was set up as to identify the effect of different sensory profiles and specifically different flavours on the emotional profiles of milk and dark chocolates. The two chapters in this part aim to identify what drives a consumer to purchase and consume chocolate with specific attention on how anticipated emotions influence this process.

The findings from Part I on the key sensory attributes and the studied effect of flavours on emotional profiles from Part II, are brought together in the Part III which focusses on consumer-driven product development or improvement. Chapter 6 encompasses the concept of Quality Function Deployment in which the consumer needs, technical requirements of the product, the evaluation of competitor products and even evaluation of trained sensory panel is taken into account. Moreover, this chapter also studies the possibilities and bottlenecks of this methodology regarding the application in the food industry. Chapter 7 is a review paper on how conjoint analysis which is known to be a marketing tool can be combined with sensory analysis in order to cover both extrinsic and intrinsic attributes. This methodology can be of great value for product developers as both types of attributes are connected to consumers' preference and choice. Chapter 8 contains

the final experiment of this doctoral dissertation. Here the findings from chapter 7 are used to set up an experiment in which tasting and thus an intrinsic attribute is part of the conjoint analysis.

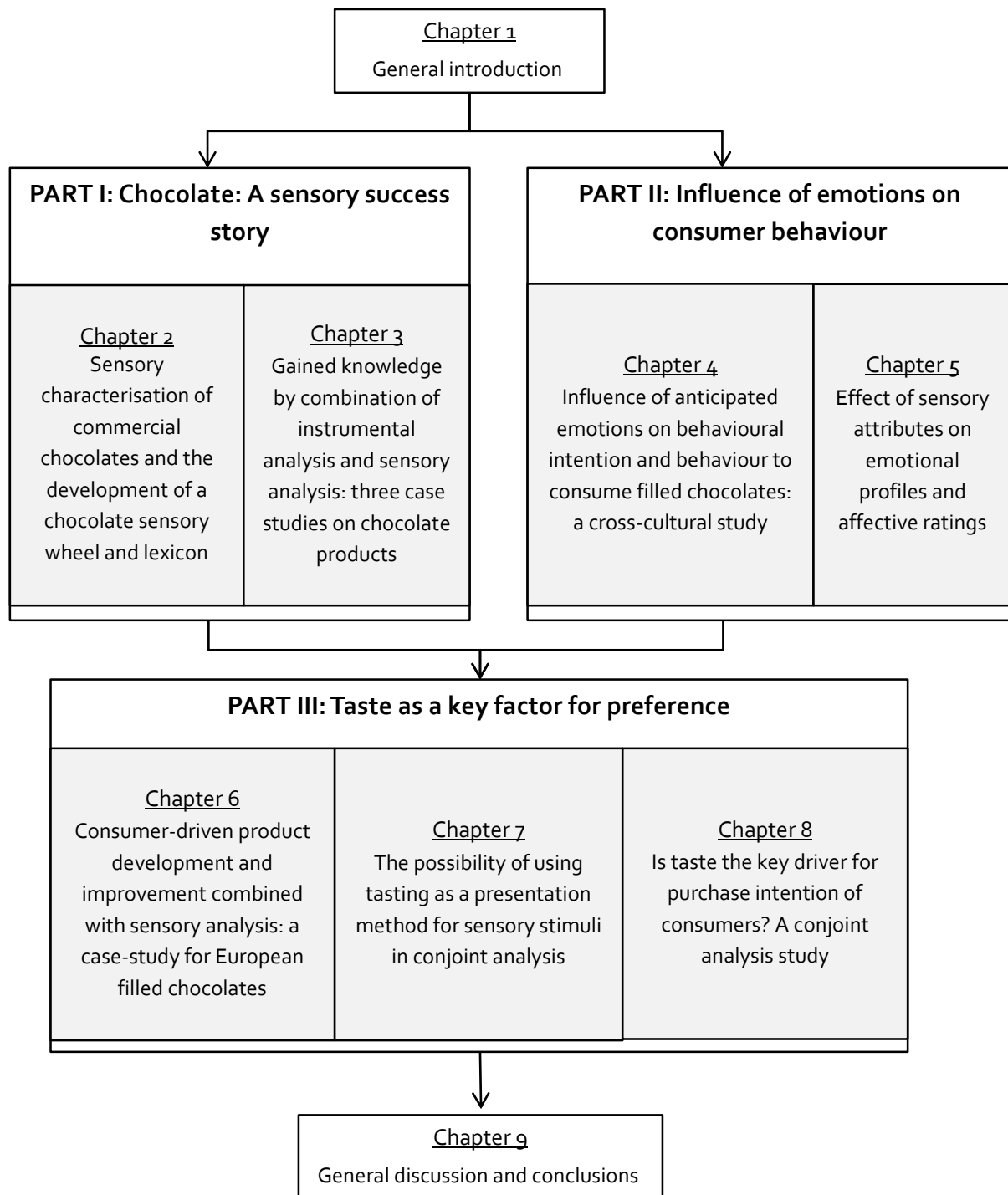


Figure 1. 5: Thesis outline

1.4. *Research objectives and research questions*

The overall objective of this research is to investigate key drivers for consumer preference related to chocolate products. Understanding the influencing sensory characteristics, grasping the motives and attitudes towards chocolate consumption and identifying the most important extrinsic and intrinsic attributes which lead to preference are necessities in successful product development.

This section specifies the main research questions of the present work, which were developed in line with the conceptual framework described above. Three main research objectives are distinguished, leading to six research questions. Each of these questions is addressed and answered in the three parts of the dissertation.

Part I: Chocolate: A Sensory success story

Research objective 1: Identification of key sensory attributes of chocolate
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In this first part, the sensory attributes for defining chocolates are collected. Further, the correlation between sensory analysis and instrumental analysis is used to explore the gaps and correlations between these two characterization methods. This first part focuses on the '**voice of the company**' and covers the **objective food quality** (Figure 1. 4). This first research objective focuses on the ability of sensory and instrumental analysis to measure and verify certain attributes.

Two research questions are formulated. The first research question asks:

RQ1: What are sensory attributes that consumers use to assess the quality of chocolate?

Previous studies indicated that chocolate consumption is mostly driven by arousal of sensory pleasure (Mela, 2000, Parker et al., 2006, Torres-Moreno et al., 2012). As an answer to this question, a sensory wheel for chocolate was developed in chapter 2. These sensory properties are defining factors for the quality of chocolate (Popov-Raljac and Lalovic-Petronijevic, 2009). Two types of methods are used to quantify these sensory properties, namely human sensory measurement and instrumental measurement. Therefore, the second research question and two subquestions ask:

RQ2: How can sensory analysis contribute to characterise physical product features?

RQ2a: Is sensory or instrumental analysis the most appropriate method to characterise chocolate products?

RQ2b: Which insights does sensory analysis provide on product acceptance?

Several research papers have studied the correlation between sensory and instrumental data (Lee et al., 1999, Gambaro et al., 2002, Martinez et al., 2007, Guinard and Mazzucchelli, 1999, Andrae-Nightingale et al., 2009). Next to the correlation, chapter 3 focuses also on the

possible gap between and thus the complementary aspects of sensory and instrumental analysis.

Further, previous research indicated that consumers base their overall liking and food choice on their sensory perception and sensory properties (Torres-Moreno et al., 2012). Numerous studies have measured acceptance (liking) as the main driver for preference and food choice (de Graaf et al., 2005, Drewnowski, 1997, Hellemann and Tuorila, 1991, Hetherington and Macdiarmid, 1995).

Part II: Influence of emotions on consumer behaviour

Research objective 2: Understanding the attitudes and emotions towards chocolate consumption.

The second part looks into the '**voice of the consumer**' which consists of the **subjective food quality** which is perceived by the consumer and the **personal characteristics** (Figure 1. 4). Both the experience of quality cues as the personal characteristics play an important role in the final consumer behaviour. In this part, the research focuses on the influence of emotions on both perception and acceptance.

Köster (2009) defines food choice as a routine or habit because consumers do not process new information each time they purchase a food product. These habits and routines need to be taken into account when identifying current behaviour. However, repeated purchase is driven by sensory quality (Haddad et al., 2007). An integrated approach is necessary to study all these aspects to get a better understanding of consumers' behaviour. Research stated that the popularity of chocolate is related to the emotions it evokes (Macht and Dettmer, 2006, Parker et al., 2006).

In a next chapter, not only beliefs towards chocolate consumption, but anticipated emotions are investigated to answer the third research question:

RQ3: How do anticipated emotions affect the behavioural intention and behaviour of consuming chocolate?

Understanding these consumer's emotional responses to food can be a step in more successful product development (Cardello et al., 2012, Gutjar et al., 2015, King and Meiselman, 2010). Sensory properties are known to influence emotional response to food. Desmet and Schifferstein (2008) state that smell and taste are most often mentioned as eliciting emotions. Jiang, King, & Prinyawiwatukul (2014) indicate that tasting samples can make a difference in emotion profiles as emotions can be produced, reinforced, eliminated or weakened during tasting. This raises the fourth research question:

RQ4: How do sensory profiles influence emotional profiles and affective ratings?

These emotional responses lead to emotional profiles for a specific product or product group (Gutjar et al., 2015) which can help to predict liking of this product or product group (Dalenberg et al., 2014, Spinelli et al., 2014a, Ng et al., 2013a). Given these previous studies,

two sub questions are formulated as one study focuses on texture attributes and two other studies on flavour attributes:

RQ4a: What influence does a more positive emotional profile have on acceptance of chocolates?

RQ4b: Do different flavours in chocolate evoke different emotional profiles?

Part III: Taste as a key factor for preference

Research objective 3: Additional knowledge generated for integrating sensory analysis in new product development.

Part III studies how both the **objective** and **subjective quality cues** lead to overall preference and consumer behaviour (Figure 1. 4). This last part aims to indicate how the subjective quality cues can lead to alteration of the objective quality cues (Chapter 6) but also how the intrinsic and extrinsic quality cues can be combined to construct an ideal product (Chapter 7 and 8).

As product failure rate in the food industry is high, there is an increasing demand for well-defined procedures leading to new product development (Moskowitz and Hartmann, 2008, Moskowitz et al., 2006, Craig and Hart, 1992). The total food quality model (Steenkamp, 1990) indicates that although a first purchase might be more initiated by extrinsic attributes, a repurchase of products is driven by both extrinsic attributes and intrinsic attributes of which sensory attributes are the most important. Given that sensory characteristics are key in purchase of food products (Köster, 2009), two frequently used methods when composing new or improved products are extended with sensory analysis. Two research questions were formulated each related to one method. The fifth research question is formulated as:

RQ5: What are the opportunities and bottlenecks when including sensory analysis in consumer-driven product development?

To answer this question the quality function deployment (QFD) is used, as it is considered to be a method that integrates goals from departments while considering consumer's requirements (Holmen and Kristensen, 1998).

In developing new products, both intrinsic and extrinsic attributes need to be taken into account. Conjoint analysis is traditionally used to define the most important product attributes in consumers' choice (Mesías et al., 2013). Moreover, it is often used in the food industry for new product development (Moskowitz and Silcher, 2006, Asioli et al., 2014, Naes et al., 2010b). Several studies indicated that integrating sensory differences in conjoint task can improve the validity of the method (Helgesen et al., 1998, Hoppert et al., 2012). The sixth and final research question asks:

RQ6: Whether tasting is the most important attribute for consumer preference?

1.5. *Intended research and practical contribution*

1.5.1. Intended scientific contribution

All the intended research contributions are summarized in Table 1. 1.

As Part I will focus on how sensory analysis can be relevant for product and process optimization, both methodological and empirical contributions will be delivered. In terms of methods, a sensory wheel will be developed. This is innovative as it will not only include aroma or flavour attributes (Reed, 2010) but also appearance and texture attributes. Moreover, this wheel will be set up based on input from the consumer instead of chocolate experts or technologists. Throughout this dissertation, the focus is always on the consumer and everything starts from this perspective. Through the experiments conducted and presented in chapter 3, the intention is to indicate show the necessity of using sensory analysis in the food industry. By comparing instrumental and sensory evaluations possible interactions or complementary aspects can be revealed.

Table 1. 1: Intended research contribution

Contribution area	Contribution level	
	Extension	Innovation
<i>Methodological</i>	Emotions: Chapter 4 New product development: Chapter 8	Relevance sensory analysis: Chapter 2 New product development: Chapter 8
<i>Empirical</i>	Relevance sensory analysis: Chapter 3 Emotions: Chapter 5 New product development: Chapter 6, Chapter 8	Relevance sensory analysis: Chapter 3 New product development: Chapter 7, Chapter 8

Part II focuses on consumer behaviour and specifically emotional aspects of chocolate consumption. Here, the idea is to deliver an extension to an existing method namely TPB to study if these anticipated emotions have an influence on the behavioural intention and behaviour of consumers towards eating filled chocolate. Moreover, experiments are conducted to identify if differences in sensory characteristics can result in a difference in emotional profile of chocolate products. These can be valuable information to implement when developing and marketing a new product.

In the final Part III, different elements are brought together in the framework of new product development. On the methodological side, the influence of an attitudinal questionnaire on the results of a conjoint analysis is studied. This will provide insights in how a questionnaire can be constructed. Further, chapter 9 presents the first experiment in which results of a conjoint analysis with a verbal description of taste is compared to the results of a conjoint analysis in which tasting is incorporated as an attribute. These two experiments are conducted simultaneously and thus eliminates possible bias due to surroundings. This is the first study that will research the effect of actual tasting in a conjoint analysis.

From the empirical perspective, this Part III will discuss the theoretical possibilities to include sensory analysis in conjoint analysis. A literature review (chapter 8) discusses previous studies and identifies the problems in the implementation. In chapter 6, a critical summary is made of the bottlenecks when using house of quality in new product development.

1.5.2. Practical relevance for the food industry

This doctoral research also seeks to be of practical relevance for the food industry and stakeholders in the field of sensory analysis and product development. It broadly addresses the value of including sensory analysis as a necessary step in product development as it provides insight in mechanisms that influence the production of the product and the acceptance of the consumer. In every chapter, a suggestion is made on how the outcomes of that specific chapter can have an influence or serve as input information in the Stage-Gate® process. In the concluding chapter, an overview will be presented on how different aspects of sensory analysis can be included in this new product development method.

From R&D perspective, the knowledge gap between what is measured in the lab and what the consumer thinks of the sensory characteristics of a product is essential. Significant differences that are clearly measured in the lab can be of no value to the consumers, as they might not be able to perceive these differences. This will be addressed in Part I. As will be demonstrated in the study on graininess, this can also have an effect on the processing conditions. On the other hand, this doctoral research will also show that changing one sensory characteristic can have an effect on other sensory characteristics. Therefore, a thorough understanding of the objective but also subjective sensory properties is a necessity in developing new products or improve existing products.

From marketing perspective, a first interesting aspect is the development of the sensory wheel. Knowing the sensory drivers for product purchase offers options to set-up the most optimal marketing mix. Such a sensory wheel can be created for every product or product group produced by a company. The differences among these wheels can help to differentiate marketing focus. However, a marketer should always be aware that a product is not fitted for 'everyone'. Grasping the differences in beliefs, attitudes and motives between the different segments can help to position a specific product on the market supported by the suitable extrinsic attributes. Next to these personal characteristics, the current literature states that emotions play an important role in consumer acceptance. A marketer can get important information from the emotional profiles of different products. This again can help them to create the most appealing marketing communication or promotion.

Finally, the trade-off between extrinsic and intrinsic products is a topic that is highly important when defining the key characteristics of a product. Again, the importance of segmentation is clearly indicated. Whereas some consumers are more driven by extrinsic attributes such as brand or price, others are most influenced by the intrinsic attributes for example the sweet taste of a product.

1.6. *Research design and data sources*

This doctoral research uses both primary and secondary data sources. Primary data were collected through the use of qualitative, quantitative and experimental research procedures. Table 1. 2 gives an overview of the data collected and used in this dissertation. In line with aforementioned research objectives, quantitative data was collected in one consumer survey which was conducted in Belgium and Hungary. Sensory evaluation of food products also provided quantitative data. A chocolate trained panel was set-up for discriminative and descriptive analysis whereas five different consumer tests were conducted to capture the voice of the consumer. Further, instrumental analysis was used to get a better understanding of the used products. Qualitative data was collected through focus groups conducted in two studies. Experimental data was collected in the ninth chapter to study the influence of tasting in conjoint analysis. Secondary data were used as input information for the qualitative research and to review the current use of sensory analysis in conjoint methodology.

A more detailed description of the primary data assembled in the different study samples and methodologies applied, are included in the methods section of the respective chapters. The present section provides a brief overview of the methodologies used following the overview presented in Table 1. 2.

1.6.1. Primary data

1.6.1.1. *Qualitative data*

Two qualitative studies were conducted, one in chapter 2 and another in chapter 9. Both were conducted to collect key characteristics to include in the following quantitative study. Focus groups were conducted according to standard procedures (Morgan, 1997). The number of participants in the focus groups were based on general guidelines for conducting focus group research. Morgan (1998) recommended to use six to eight participants in every group. For each study, the total number of participants was based on practical and saturation criteria. For both qualitative studies a guideline was developed prior to the focus groups. These guidelines are further discussed in the respective chapters.

Table 1. 2: Research design and data sources

		Part I: Chocolate: A sensory success story				Part II: Influence of emotions on consumer behaviour				Part III: Taste as a key factor for preference			
		<u>Chapter 2</u>		<u>Chapter 3</u>		<u>Chapter 4</u>		<u>Chapter 5</u>		<u>Chapter 6</u>	<u>Chapter 7</u>	<u>Chapter 8</u>	
		Study 1	Study 2	Study 3	Study 4a*	Study 5	Study 4b*	Study 6	Study 7	Study 8		Study 9	
										Literature review			Secondary data
Qualitative		n = 48								n = 15			Primary data
Quantitative	Instrumental analysis	Colour Hardness SFC DSC PSD	Colour Hardness	Hardness DSC PSD	Colour Hardness DSC					Colour Hardness			
	Sensory analysis trained panel (n = 9)	QDA	QDA	Ranking Triangle QDA	QDA	QDA				QDA			
	Sensory analysis consumer			n = 54	n = 131	n = 131		n = 156	n = 930	n = 222			
	Consumer survey					n = 859**				n = 859**			
Experimental										n = 2407			

SFC = Solid Fat Content; DSC = Differential Scanning Calorimetry; PSD = Particle Size Distribution; QDA= Quantitative Descriptive Analysis (these analyses were applied to different samples in the indicated studies)

* The data collected in Study 4 were divided among two chapters, ** This dataset was used in Study 5 and Study 8.

The results of both qualitative studies were used as input information for the quantitative studies that were conducted in both chapters.

1.6.1.2. Quantitative data

In this doctoral research, quantitative data was obtained by instrumental analysis, sensory analysis and consumer surveys. The specificities of every measurement is discussed in the respective chapter, but an overall introduction to the methodologies is presented below.

Instrumental analysis

- Colour measurement

All colour measurements in this research were conducted on a Minolta Model CM-2500D spectrophotometer (Konica Minolta Sensing Inc., Osaka, Japan). The Minolta measurements are expressed in L* value for lightness, a*value for redness and b* value for yellowness. These data was in used in chapter 2 to retrieve information on the dominant colour of the chocolate by calculating the hue (h°) – value or the colour saturation of the purity of the dominant colour by calculating the Chroma (C*) – value (De Clercq, 2011). In chapter 3 and 6, the L*, a* and b* - values were used to calculate the whiteness index (WI). This is an indicator for the development of fat bloom on the surface of chocolate (Altimiras et al., 2007, Anonymous, 2007, Bricknell and Hartel, 1998). For the data to be reliable, colour measurements are done on several samples and on several random places of every sample.

- Texture measurement: hardness

Texture measurements to determine the hardness of plain chocolates in this research, were conducted with an Instron 8942 Texture Analyzer (Instron, Massachusetts, USA) through a penetration test (Chapter 2 and Chapter 3, study 3 and 4). This test measures the force necessary to break the chocolate. For filled chocolates, the TA500 Texture Analyzer (Lloyd Instruments Ltd., West Sussex, UK) was used to perform the three point bent test (Chapter 3, Study 2 and Chapter 6). This test measures the fragility of the filled chocolates, which is defined as the force required to fracture a material (Scheffé, 1952). This parameter is defined by Jaeger et al. (2008) as a combination of hardness, the forces required to compress a substance between the molar teeth and the cohesiveness, the degree to which a substance is compressed between the teeth before it breaks, of food products.

For both types of texture measurements, repetitive measurements were necessary to obtain reliable results.

- Solid Fat Content (SFC)

The solid fat content (SFC) of the extracted fats is measured by the Maran Ultra NMR (Oxford Instruments, Oxford, UK) according to the pulsed NMR-method. The SFC provides

information on the melting rate of the fats in the chocolate samples. The reliability of these measurements is high, therefore only a few samples need to be analysed.

- Differential Scanning Calorimetry (DSC)

Differential Scanning Calorimetry (DSC) is conducted with a TA 2010 DSC (TA Instruments, Brussels, Belgium) with refrigerated cooling system. This type of measurement are used to determine the melting profile and the crystallization of chocolate products. Specific parameters such as onset temperature (T_{onset}), peak temperature (T_{peak}), end temperature (T_{end}) and enthalpy of melting (ΔH_{melt}) are calculated based on the DSC thermogram. Based on these indicators chocolates can be differentiated based on their melting properties. These measurements are reliable, therefore only few samples are necessary for the analysis.

- Particle size distribution (PSD)

Particle size distribution (PSD) is measured with the 2000 S Mastersizer (Malvern instruments Ltd, Worcestershire, UK). The PSD is quantified as the relative volume of the particle size in relation to the particle diameter. These analyses provide PSD curves and values for the $D_{4,3}$, $D_{v,10}$, $D_{v,50}$ and $D_{v,90}$. The particle shape is not taken into account in these measurements. For every type of chocolate that needs to be analysed, a large number of repetitions needs to be done to get reliable results. The specific procedures are explained in the respective chapters.

Sensory analysis

In the field of sensory analysis, evaluations can be conducted with trained panellists or consumers. Both are used in the doctoral research as they provide complementary data for the evaluation and understanding of the sensory characteristics of chocolate products.

- Trained panel

For this doctoral research, a trained panel was set-up. This panel was used to discriminate between samples and create sensory profiles of the used chocolate products when necessary.

A trained sensory panel normally consists of 6 – 12 people. This panel consisted initially of 9 and later on of 8 assessors, selected from a pool of ~50 possible candidates. Selecting and training people to be part of a trained panel is a time-consuming task. An overview of the different steps in the training is given in Figure 1. 6. Assessors were selected and recruited in compliance with ISO (8586:2012) standards and participated in a 3 month training period (Murray et al., 2001). These ISO standards are guidelines for the set-up of a trained panel. The respondents were selected based on their abilities to identify and describe differences in chocolate and filled chocolates and their ranking of different concentrations of ingredients of chocolate.

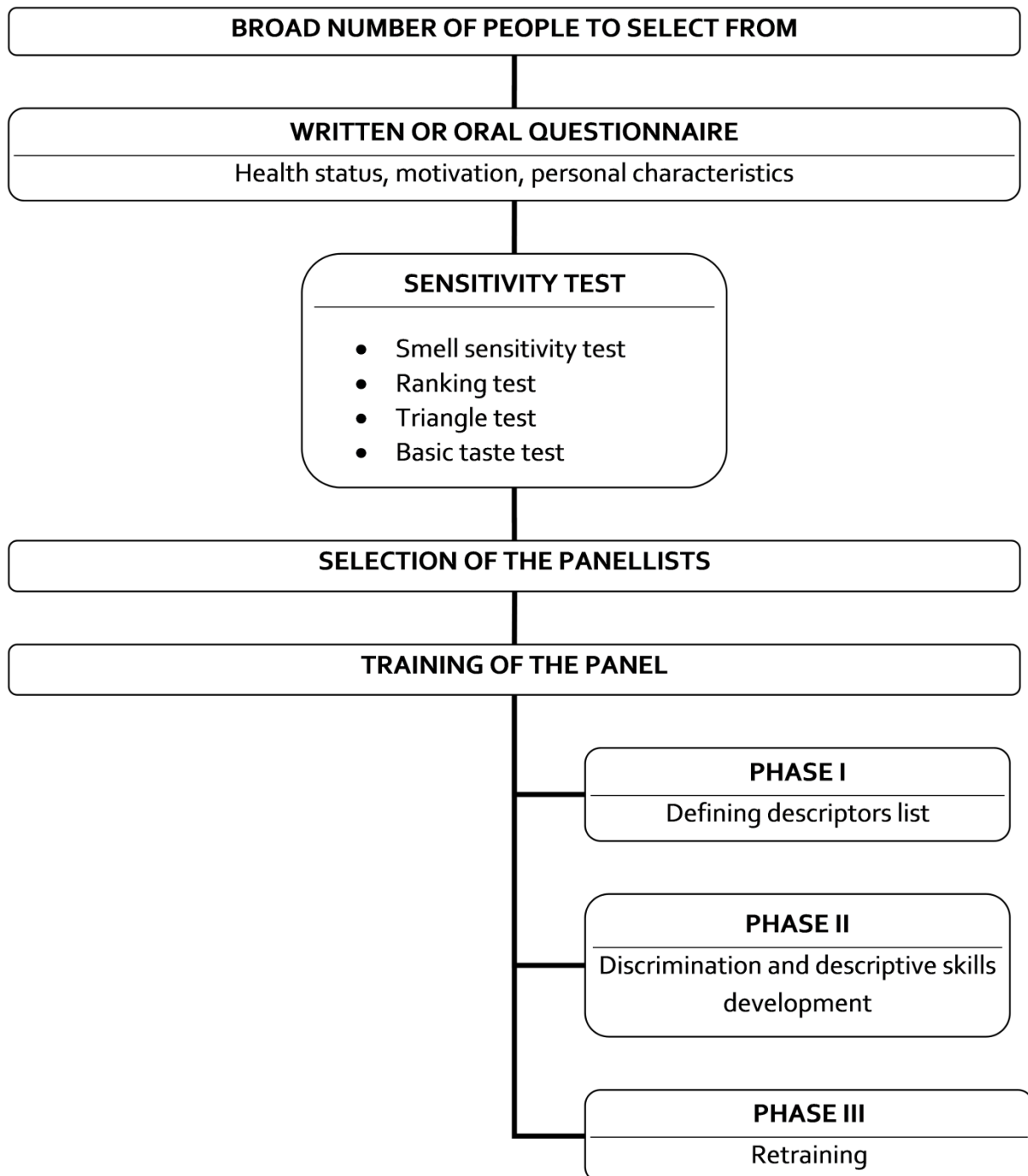


Figure 1. 6: Overview of the selection, screening and training of a sensory panel

First, several communication activities were set-up to inform and give people working and studying at Ghent University the opportunity to participate in the preliminary recruitment of possible candidates for the trained panel. This preliminary recruitment of people is based on a written or oral questionnaire. Information is collected on the health status, motivation, and personal characteristics of the different persons. Based on these questions a first selection is performed.

In a second step, these selected people came to the UGent SensoLab to participate in various selection tests in order to identify the most sensitive participants. Four different tests were conducted: aroma sensitivity tests, ranking test, triangle test and basic taste test.

In the aroma recognition tests, the selected people were asked to describe which aroma they detected. The aroma test was carried out according to ISO 8586-1:2001. The participants were presented with 5 jars containing different olfactory stimuli. The candidates were evaluated according to their performance on the following scale:

- points for correct identification or description of the most frequent associations
- points for a description in general terms
- 1 point for an attempt to describe the smell, or a description of an appropriate association following discussion
- 0 no response

In the ranking test, the respondents were asked to put solutions from basic tastes in the right order from high to low concentration. This test was done with sweet and sour taste. For every taste the assessors received 6 samples in different concentrations.

In a triangle test, assessors evaluated three samples. Two samples were solutions of a basic taste with the same concentration. The third sample had a different concentration of the same basic taste. This is another way to define the sensitivity of a person for the different levels of a taste.

The next test was a basic taste test. In this test, the assessors received samples of different “taste qualities”: sour, bitter, sweet, salt, umami and metallic. Within each taste, they received eight samples. First, the assessor had to indicate which taste he/she perceived and then indicate the intensity of the taste. The concentrations were provided by Campden BRI and are consistent with ISO – standards (ISO 3974).

The above described methods were used in the first selection test. A second selection was done with the same methodologies but now different chocolate samples were used. After these tests, the best performing assessors were selected for the trained panel. In conclusion, the panellists were selected based on their abilities to identify and describe differences in chocolate and filled chocolates and their ranking of different concentrations of ingredients of chocolate.

After the selection, the actual training of the panellists started.

The aim of the first phase of the training is always to collect sensory descriptors for the researched products. This list is always gathered through a discussion session with the panellists. During this discussion session, the panellists established a list of attributes through evaluation of different types of chocolate. Then, an accurate definition for these attributes was prepared. The main objective of this qualitative phase is to ensure that all assessors accept and understand the attributes.

After these sessions, the panel leaders developed a standard procedure by which panellists evaluated several chocolates for the descriptive analysis of chocolate products. At every session, some discriminative analyses needed to be completed as well to also familiarize the panellists with these type of analyses. Continuous panel performance and monitoring techniques were used to ensure all assessors maintained a high level of competence (Moussaoui and Varela, 2010). The panellists were trained over a period of 10-15 hours to perform quantitative descriptive analysis (Murray et al., 2001). The products were then evaluated in repeated trials to obtain quantitative description and reliable, consistent results (Jones et al., 1989, Lawless, 1984).

For every evaluation conducted within this doctoral research, the panellists were retrained. For the evaluation in chapter 2, they were retrained on evaluation of white, milk and dark chocolates. In chapter 3, the panellists were retrained with a focus on evaluating filled chocolates (study 2), on texture and more specifically graininess of dark chocolates (study 3), and texture of milk chocolates (study 4a). The retraining necessary for the evaluations in chapter 6 concentrated on an extensive evaluation of filled chocolate subject to fat bloom or cracking.

- Discriminative analysis

For discriminative analyses, triangle and ranking tests were used. These methods are used to identify significant differences between the samples.

Triangle test

In the triangle test, three samples are presented simultaneously to the panellists, two samples are from the same formulation and one is from the different formulation (Meilgaard et al., 2007, Lawless and Heymann, 2010). Each panellist has to indicate either which sample is the odd sample. The null hypothesis for the triangle test states that the long-run probability of making a correct selection when there is no perceptible difference between the samples is one in three ($H_0: P_t = 1/3$). The alternative hypothesis states that the probability that the underlying population will make the correct decision when they perceive a difference between the samples will be larger than one in three ($H_a: P_t > 1/3$). The triangle test allows the sensory specialist to determine if two samples are perceptibly different but the direction of the difference is not indicated by the triangle test.

Ranking test

A ranking test is used to determine panellists' ability to discriminate graded levels of intensity of a given attribute. Here, samples are presented in random order. One parameter is present at different levels, covering the range present in the product(s) of interest. Panellists are asked to rank the samples in ascending order (or rate them using the prescribed scale) according to the level of the stated attribute (sweetness, oiliness, stiffness, surface smoothness, etc.) (ISO 8587).

- Descriptive analysis

Quantitative Descriptive Analysis (QDA) was used as descriptive analysis in this doctoral research (Meilgaard et al., 2007, Lawless and Heymann, 2010). QDA has many advocates and the technique has been extensively reviewed (Lawless and Heymann, 2010, Meilgaard et al., 2007, Stone and Sidel, 2004b, Murray et al., 2001). As discussed above, panellists are exposed to many possible variations of the product during the QDA training. The choice of range of samples is dictated by the purpose of the study and panellists generate a set of terms that describe differences among the products. Then through consensus, panellists develop a standardized vocabulary to describe the sensory differences among the samples. The panellists also decide on the reference standards and/or verbal definitions that should be used to anchor the descriptive terms. Actual reference standards are only used about 10% of the time; usually, only verbal definitions are used (Murray et al., 2001).

In addition, during the training period the panel decides the sequence for evaluating each attribute. Later in the training sequence, a series of trial evaluations are performed. This allows the panel leader to evaluate individual judges based on statistical analysis of their performance relative to that of the entire panel. Evaluations of panellist performance may also be performed during the evaluation phase of the study.

Richter (2010) states that QDA is an appropriate tool to use when evaluation requires detailed information on the sensory profile of food products specifically on the identification and on the quantification of the attributes. It can be used when products need to be compared or when standards for quality control need to be assessed. Moreover, it is a useful tool to make correlations with instrumental measures (Kronold et al., 1983). When the assessors are sufficiently trained in attribute recognition and scaling, they will use the sensory language they agreed on. The products are then evaluated on repeated trials to obtain quantitative description and reliable, consistent results (Jones et al., 1989, Lawless, 1984).

QDA data can be analysed by both univariate and multivariate statistical techniques. Statistical procedures such as multivariate analysis of variance, principal component analysis, factor analysis, cluster analysis have found application in the analysis of data generated by QDA-type procedures (Meullenet et al., 2007, Dijksterhuis and Piggott, 2000). Graphical presentations of the data often involve the use of "spiderweb" graphs. There is some argument about the assumption of normal distribution of the data set and hence the use of parametric statistics such as analysis of variance, t-tests. A few authors feel that non-parametric statistical treatment of the data is required (O'Mahony, 1986), but this appears to be a minority opinion.

- Consumer panel

Sensory tests can be used to quantify the degree of liking or disliking of a product, called hedonic or affective test methods. Consumers are used as respondents for these tests. In the

past, these tests were constructed solely out of acceptance or preference tests (Stone and Sidel, 2004c). Today, the Just-About-Right (JAR) scale is frequently used to get a better understanding of the consumers' preferences (Jaeger et al., 2015). The JAR scales are popular for the direct information that they give on specific attributes to be optimized. Product developers like this information and so do managers. Furthermore, the concept of deviation from ideal taps into a basic decision when we react to products. For example, people commonly say that the coffee is too strong or too weak or that the wine is too sweet or too tannic. The most obvious application of this information is in optimization of a product's key attributes. Intensity and hedonic judgments are combined to provide directional information for product reformulation. Therefore both acceptance and JAR-scales were used in the consumer tests in this doctoral research.

In chapter three, two consumer tests were conducted, the first in study 3 and the second in study 4a. The test in study 3 was an explorative consumer test to find out if the results are in line with the results from the trained panel. Therefore only a few consumers were recruited and these results cannot be generalised for the whole population. For the consumer test in study 4a, consumer were selected on different criteria. Specifics of the tests are provided in chapter 3.

Chapter 5 also comprises three consumer tests in study 4b, study 6 and in study 7. The general aim of this chapter is to explore if different sensory characteristics of milk chocolates and further different flavours of dark chocolate evoked different emotion ratings when tasting the product. Recent studies indicated that the understanding of consumers' emotional responses to food can provide additional information for product development (Gutjar et al., 2015, King and Meiselman, 2010, Thomson et al., 2010). Further description of the questionnaires, respondents and samples can be found in chapter 5.

In Chapter 6, a cross-cultural study was conducted in Belgium and Hungary with 222 consumers was conducted within the framework of ProPraline.

Details on the design of the study are provided in chapter 6.

Consumer survey

A large-scale consumer survey was performed in both Belgium and Hungary within the framework of the ProPraline – project. The study aimed to gain insights in consumer behaviour towards eating chocolate by identifying the respondents' beliefs and attitudes leading to the behavioural intention and behaviour to consume chocolate. The data gathered in this large consumer survey served as input for chapter 4 and 6. By using an extension to the theory of planned behaviour in chapter 4, the influence of anticipated emotions on behaviour and behavioural intention to consume chocolate. For chapter 6, only the importance ratings for appearance, aroma, texture and flavour for food products in general are used as input information on the consumer' needs for the House of Quality which is composed in chapter 6.

1.6.1.3. *Experimental data*

A final data collection (=2407) was conducted at public fair. This dataset was gathered by conducting an actual experiment whereas in previous quantitative studies all respondents answered identical questionnaires. In this study, an experimental design was set-up to split up the respondents in different groups which were subjected to a different treatment. This study aimed to incorporate tasting of chocolate as a presentation stimuli in conjoint analysis. Whereas conjoint analysis is traditionally used to capture extrinsic attributes, this experiment tested the importance of an intrinsic, sensory attribute in the composition of an ideal product for a consumer. As no previous study was published in which the comparison was made between a conjoint test with and one without tasting, this experiment provides valuable insights in how sensory evaluation can be built in a frequently used marketing tool. The design of this experiment is thoroughly explained in chapter 8.

Part 1

Chocolate:

A Sensory success story



Chapter 2

Sensory characterization of commercial chocolates and the development of a chocolate sensory wheel and lexicon

Adapted from:

De Pelsmaecker, S., Schouteten, J., Lagast, S., Dewettinck, K., Gellynck, X. Sensory characterisation of commercial chocolates and the development of a chocolate sensory wheel and lexicon (*In preparation*)

Abstract

For many consumers, the sensory arousal is the most important experience when consuming chocolate. Chocolate sensory quality can be divided into four sensory areas: appearance, aroma, texture and taste. These domains are defined mainly by ingredient composition and the chocolate production process.

This study aims to identify sensory characteristics with respect to the four sensory groups, which are important for chocolate consumption and visualize them in a chocolate sensory wheel. Based on the descriptors obtained from the consumer, three commercial brands for white, milk and dark chocolate were characterised with instrumental analyses and with a trained sensory panel. A comparison of the instrumental and sensory results was made between white, milk and dark chocolate and within those groups. The correlation between the instrumental and sensory results was assessed by visual interpretation and representation in PCA graphs.

The development of this chocolate sensory wheel can help product developers in new product development. Identifying, understanding and using the sensory characteristics that are most important to a consumer is crucial. By applying the chocolate sensory wheel for nine commercial samples, it was clear that the attributes included in the sensory wheel can differentiate commercial samples.

2.1. Introduction

Literature indicates that chocolate consumption is mostly driven by the arousal of sensory pleasure due to the specific melting behaviour, aroma and taste of chocolate (Januszezewska and Viaene, 2002, Mela, 2000, Parker et al., 2006). Consequently these parameters are key factors in the production, storage and marketing of chocolate (Afoakwa, 2010). The sensory characteristics of chocolate are the result of the total production, starting from the selection of the ingredients.

As indicated in the introduction, the use of different cocoa bean varieties results in different flavour profiles of the chocolates. The composition of the cocoa beans, the botanical origin, the growth location and agricultural circumstances define the flavour potential for every bean (Afoakwa, 2010). Fermentation is essential for the development of the flavour profile as the flavour precursors are created in this stage of the processing. After fermentation, the beans are dried to get a good brown colour, low astringency and low bitterness. The absence of off-flavours and smoky aromas are indications of a good drying process (Awua, 2002). The roasting of the beans is an important step in the transition of the flavour potential to the actual flavour profile (Afoakwa, 2010). During this roasting process, the Maillard reaction creates the classic chocolate and nutty flavours (Afoakwa et al., 2007, Fowler, 1999). The final chocolate taste is developed during grinding. The nibs of the cocoa beans are grinded to a particle size below 30 μm (De Pelsmaecker et al., 2014) as it is believed that this is the threshold at which particles can be detected by humans. Controlling the particle size distribution is necessary to get a soft and smooth mouth feel and avoid a grainy mouth feel (Beckett, 2009, Beckett, 2000). The next step in the processing of the beans is conching. This is a crucial step for the development of the viscosity, final texture and flavour of the chocolate. In order to get the correct viscosity, lecithin is added at the end of the conching step. It is also possible to add extra cocoa butter or a cocoa butter equivalent (CBE) before starting the tempering step (Beckett, 2000, Afoakwa, 2010, Awua, 2002). Well-tempered chocolate has a good texture, shape, colour, gloss and contraction. It also prolongs the storage capacity of the chocolate (Depypere et al., 2009a).

Next to the processing, the ingredients are crucial for the flavour profile of chocolate. Cocoa has a natural bitter taste which is caused by the presence of polyphenols and alkaloids. In order to prevent the chocolate of being too bitter, sugar is added. A change of 5% in the amount of sugar added causes an effect on the flavour. Sucrose is mostly used in chocolate confectionary, lactose in milk chocolate (Beckett, 2009). The size of the sugar particles is also crucial for a smooth mouth feel. Therefore it is important to control the sugar particle size distribution during grinding and refining (Afoakwa, 2010). In the production of milk chocolate, milk powder needs to be added. This contains milk fat which softens the chocolate. Milk fat is not sensitive for oxidation and influences the shelf life of the chocolate (Beckett, 2000, German and Dillard, 1998).

The final characteristic that influences the sensory aspects of chocolate is storage. When the perishable date is exceeded, the quality of the appearance and the taste will decrease (Andrae-Nightingale et al., 2009, Depypere et al., 2009a). To prevent this from happening, the storage temperature is very important as chocolate is very sensitive for temperature fluctuations and heat. The ideal storage temperature for chocolate ranges from 14°C – 18°C (Ghosh et al., 2002).

This study was conducted to characterize and quantify the importance of the sensory attributes that are decisive factors in the choice of the consumer. Focus groups were organized with chocolate consumers to find, discuss and evaluate the sensory descriptors of white, milk and dark chocolate (Lawless and Civille, 2013). The significant descriptors and their relative importance were assembled in a simple and convenient format by developing a sensory wheel that reflects the variation in white, milk and dark chocolate for appearance, aroma, texture and taste.

This wheel format has been used for some product categories in previous studies (Bérodier et al., 1997, Theron et al., 2014, Koch et al., 2012, Mojet and de Jong, 1994, Warm et al., 2000). Koch et al. (2012) assembled 27 attributes for flavour, taste and mouth feel to describe rooibos tea. The focus was primarily on flavour and taste. Warm et al. (2000) put together a sensory wheel for five fish species including appearance, texture, aroma and taste. Here, the sensory wheel is developed for chocolate products and includes appearance, texture, aroma and flavour. Although there are already some sensory wheels available for chocolate products, these only contain flavour and aroma. The inclusion of appearance and texture is definitely a novelty in this paper. Moreover, the importance of the different attributes is also derived from the qualitative research. Normally these sensory wheels are developed based on the intrinsic characteristics of the product. This information can be based on ingredient composition, or on instrumental analyses (e.g. GC-MS) which defines the different aromas or flavours of a specific flavour. However, many of these aromas or flavours are not detected by consumers and more importantly do not influence the acceptance of the food product. In this study, the wheel was developed based on the input delivered by the consumers and therefore only elements that are important for consumers are depicted.

By analysing the sensory characteristics of nine commercially available samples through descriptive sensory analysis it was possible to differentiate these samples based on the sensory attributes collected in the sensory wheel. This application wanted to test if the attributes selected for the sensory wheel were able to differentiate between the chocolate samples. Instrumental analysis is also applied on these commercial chocolates in order to correlate the results from sensory and instrumental analysis.

Knowing the most important sensory drivers for chocolate consumption and combining them in a sensory wheel can be of great value for product developers specifically in SME's who do not have the possibility to conduct consumer studies to gather these sensory characteristics. This sensory wheel can thus be used as a starting point when developing new products.

2.2. *Materials and methods*

2.2.1. Chocolate samples

For the focus groups, a total of 22 commercial chocolate samples were selected as illustrations of possible sensory differences among the samples. This makes it easier for the consumer who participates in the focus groups to come up with different sensory descriptors.

When developing a sensory wheel it is necessary to include a broad range of sensory profiles in the development process and thus in the qualitative step with focus groups, to capture as many potential sensory attributes as possible. The selected chocolates were next to different in sensory characteristics also distributed over a broad range in price, brand and ingredients (Drake and Civille, 2003). After purchase, the samples were stored at constant temperature of 20°C at the Cacaolab (Ghent University).

Out of these samples, nine commercial samples, three white chocolates, three milk chocolates and three dark chocolates, were used for further sensory and instrumental analysis. The nutritional value and the list of ingredients is presented in Table 2. 1. These nine samples were selected in such a way to have at least a premium brand product and a private label product for every type of chocolate. The third sample for every type was selected based on specific characteristics of this type. For dark chocolate, an origin chocolate was selected. For white and milk chocolate, samples were chosen out the other samples in the qualitative research which were found to be different from the other selected samples. The aim was to select samples that span the sensory space for each type of chocolate.

2.2.2. Focus groups

A guideline for the focus groups was constructed (Appendix I) (Morgan, 1997). At the start of the focus group, the moderator welcomed the participants, explained that they were participating in a focus group and that the goal was to find sensory descriptors for white, milk and dark chocolate in the categories appearance, aroma, texture and flavour. A range of white (5 different samples), milk (8 different samples) and dark (9 different samples) chocolates were provided during the focus groups. The large amount of chocolate products is necessary to collect a broad range of descriptors.

The objective of these focus groups was to collect the sensory characteristics that are important for a consumer when evaluating a chocolate product. The main question that the participants had to ask themselves was: "Which chocolate do I prefer and based on which attributes do I make this choice?". The focus groups started with a discussion on the appearance of white chocolate, then the aroma, next the texture and finally the taste and flavour. Every group of sensory attributes is dealt with separately. As sensory attributes can influence one another, the moderator needs to keep the focus on the individual attributes. A second discussion covers sensory attributes for milk chocolate and a third for dark chocolate.

Table 2. 1: Nutritional value and ingredient list of the chocolates used in this chapter

	White A	White B	White C	Milk A	Milk B	Milk C	Dark A	Dark B	Dark C
<u>Price (€/kg)</u>	6.54	6.73	8.58	6.23	8.38	6.23	7.50	17.50	20.90
<u>Nutritional value</u>									
Energy (kJ/100 g)	2390	2342	2250	2241	2210	2294	No info	2367	No info
Protein %	6.4	6.6	7.3	8.2	8.3	8.3		7.5	
Carbohydrates %	55.2	55.0	60.5	54.0	54.5	51.2		52.5	
Of which sugar %	-	-	60.5	52.0	53.5	50.0		52.1	
Fats %	36.3	35.0	29.5	32.0	30.5	34.2		36.2	
Of which sat. Fats %			17.5	19.0	19.0	21.7		22.5	
Fiber %		0.0	0.0	2.3	3.1	2.0		0.9	
Sodium %		0.1	0.1	0.1	0.1	0.1		0.1	
<u>Ingredients</u>	sugar	sugar	sugar	sugar	sugar	sugar	cocoa mass	cocoa mass	cocoa mass
	cocoa butter	cocoa butter	cocoa butter	whole milk powder	whole milk powder	whole milk powder	sugar	raw cane sugar	sugar
	whole milk powder	whole milk powder	low fat milk powder	cocoa butter	cocoa mass	cocoa butter	cocoa butter	cocoa butter	cocoa butter
	cream powder	cream powder	milk fat	cocoa mass	cocoa butter	cocoa mass	cocoapowder	soy lecithin	Vanilla pod
	whey powder	whey powder	soy lecithin	lactose	whey powder	soy lecithin	emulsifier	70% cocoa	70% cocoa
	soy lecithin	lactose	aroma	soy lecithin	soy lecithin	aroma	sunflower lecithin		
	vanillin	soy lecithin	soy milk	aroma	aroma	30% cocoa	vanilla aroma		
		aroma		32% cocoa	34% cocoa		74% cocoa		

A total of 48 consumers were divided among 5 focus groups. The participants were recruited at Ghent University. In order to have a broad range in age, consumers were recruited from 18 – 75 years. All the participants were frequent (more than once a week) chocolate consumers. The number of participants in each group was determined based on general guidelines for conducting focus group research (Morgan, 1997). Specifically, to sustain the discussion and to control the group, it is recommended to select between six and eight participants (Morgan, 1997). The number of focus groups was based on practical and saturation criteria. The structured nature of the interview facilitated the achievement of saturation. After having conducted five focus groups, additional data collection would no longer yield new insights. The focus groups took place at a meeting room in which all the participants were gathered around a round table. The moderator of the focus groups made sure that everyone participated and kept the participants on track.

The participants received chocolates to take home as an incentive for taking part in the focus groups. Every focus group lasted around an hour and a half. Every participant received a ballot on which they could write down their attributes. This was an extra way of collecting information next to oral expressions of the participants.

2.2.3. Instrumental analysis

2.2.3.1. Colour

Colour measurements were conducted as described in 1.5.1.2. These a^*b^* -values can be transposed in a chroma (C^*) and a hue (h°) – value with the following equations:

$$h^\circ = \arctan\left(\frac{b^*}{a^*}\right)$$
$$C^* = \sqrt{[(a^*)^2 + (b^*)^2]}$$

The h° -value gives information on the dominant colour of the chocolate. The C^* - value gives the colour saturation of the purity of the dominant colour (De Clercq, 2011). The colour was measured ten times for each chocolate to get valid mean value as the surface colour of chocolate fluctuates frequently.

2.2.3.2. Hardness

The hardness is measured as described in 1.5.1.2. A penetration test was performed in which the cylindrical probe moves with a speed of 2 mm/s. The detection starts when a force of 0.2N is detected and ends when the probe has penetrated the sample with 5 mm. The maximum force (N) necessary to penetrate the chocolate is an indication for the hardness of the sample. The measurements were performed in ten repetitions at a room temperature of 20°C. The samples were conditioned for 1 hour to this temperature prior to the analysis.

2.2.3.3. *Solid fat content*

The solid fat content (SFC) of the extracted fats is measured according to the pulsing NMR-method (section 1.6.1.2). The SFC-curve gives information on the melting rate of the fats present in the sample at an increasing temperature. The measurements were done in a temperature range from 5°C to 40°C with a 5°C interval and an incubation time of 60 minutes. For each sample, the measurements were executed three times.

2.2.3.4. *Melting profile*

To determine the melting profile and the crystallization of the chocolate, differential scanning calorimetry (DSC) is used (section 1.6.1.2). A sample (5-10 mg) was hermetically filled in aluminium pans. An empty pan was used as a reference. They were washed with ethanol to remove fat traces and weighted (the balance had been previously tarred with the empty cup). The sample was held at 22°C for 10 min to ensure a completely solid state. Then, it was heated at 5°C/min to the desired melting temperature of 65°C. Each analysis was executed in triplicate.

2.2.3.5. *Particle size distribution*

The particle size distribution (PSD) of the nine selected samples was determined (section 1.6.1.2). Every sample is stored at 40°C for a period of 4 hours. Then, 10 mL isopropanol (Chem-Lab NV, Belgium) was added to the 0.50 g chocolate. The samples were stored between 50 and 65°C during at least 30 min before analysis to dissolve the whole sample in the solvent.

Every sample is taken out of the oven just before measurement and then shaken vigorously. A small quantity of the sample was taken with a plastic pipette and added to the system to get an obscuration between 10 and 30%. 5 measurements were performed for each sample. Since 3 samples for each chocolate were analysed, 15 measurements were carried out for each chocolate. The system was emptied and rinsed twice with isopropanol between 2 samples. The beam length was set at 2.4 mm and the analysis model was polydispersed.

The PSD is quantified as the relative volume of the particle size in relation to the particle diameter. Particle shapes were not taken into account. PSD curves, D_{4,3}, D_{v,10}, D_{v,50} and D_{v,90} were determined for all the chocolates.

2.2.4. Sensory analysis

2.2.4.1. *Quantitative descriptive analysis*

Quantitative descriptive analysis (QDA) is used to get a sensory profile of the nine chocolates by using the selected sensory descriptors. This was conducted with a trained sensory panel (Piggott et al., 1998) (section 1.6.1.2).

Although continuous panel performance and monitoring techniques were used to ensure all assessors maintained a high level of competence (Moussaoui and Varela, 2010), a retraining

on the specific sensory attributes was organised. The products were then evaluated in repeated trials to obtain quantitative description and reliable, consistent results (Jones et al., 1989, Lawless, 1984).

During the QDA test, each panellist received a blind coded sample. The samples were randomized in order to minimize the carry over and order effects. For every attribute, the assessors scored the product on a 0-9 category scale, anchored with the words 'none' and 'high.' Although Stone and Sidel (2004a) chose a linear scale to perform the QDA analysis and Lawless and Heymann (2010) recommend a 6 inch (or 15 cm) scale with anchor words, a 0-9 category scale was used here. This was requested by the panel as they preferred this type of scale to position the reference samples on this type of scale. Since it is the relative difference among the samples that is important (Lawless and Heymann, 2010), the researchers accepted this alteration.

The evaluation was carried out at the UGent SensoLab, the sensory laboratory of Ghent University. Each assessor was required to conduct the evaluations in an individual booth. The panel used filtered water and/or plain crackers as palate cleansers between the samples as recommended in research with chocolate (Lucak and Delwiche, 2009).

2.2.5. Statistical analysis

All statistical analyses were performed using SPSS 19.0. The frequency of quotation of a sensory attribute during the focus groups was used as a parameter to include in the sensory wheel. One-way ANOVA was used to analyse the quantitative data from the trained panel and in order to identify significant differences between the chocolate samples. Spiderplots were plotted to visualize these significant differences. The Tukey post-hoc test can be used as sensory analysis can be considered as parametric data (Lawless and Heymann, 2010). One-way ANOVA tests were also conducted on the data from the instrumental analyses. If the data is normally distributed and the homoscedasticity is proven, Tukey is used as post-hoc test. For non-parametric data, the Kruskal Wallis test is used as post-hoc test.

Principal component analysis (PCA) using the correlation matrix was conducted using Panelcheck (Freeware) to visualize the relationships between sensory attributes and the chocolate samples (Naes et al., 2010a).

2.3. Results

2.3.1. Sensory attributes

The complete list of 108 descriptive terms derived from 2199 answers generated during the focus groups is shown in Table 2. 2. Similar as to the study of Thamke et al. (2009), some assessors commented that it was difficult to generate descriptors different from the standard vocabulary which included attributes such as sweet, colour difference, hardness and cocoa smell and flavour.

Vannier, Brun & Feinberg (1999) indicated that an efficient sensory profiling with a trained panel is possible with about 20 attributes. Therefore, the number of attributes was greatly reduced by disregarding the attributes that were perceived by a small amount of participants (Stolzenbach et al., 2011). The reduced list of attributes used for the quantitative descriptive analysis is shown in Table 2. 3.

For appearance, there are only three attributes selected. The attributes shape and thickness are not included in the sensory profiling as these are dependent of the chocolate producer and the serving of the sample. These attributes are not inherent to the chocolate product. After discussion with the trained panel, it was decided to use the attribute graininess of the cross section instead of roughness of the surface. The panel indicated that the defects in roughness are difficult to detect without handling the product and therefore are not easy to evaluate on appearance only.

The aroma and flavour attributes are different for the three types of chocolate. The “vanilla” aroma was indicated by 44 assessors as an important aroma attribute for white chocolate. The same attribute was given by 9 and 2 participants as important for respectively milk and dark chocolate. Similarly, the “cocoa” aroma is not important for white chocolate as cocoa mass is not part of the ingredients although is highly important for milk (29 out of 48) and dark (39 out of 48) chocolate. The “fruit” aroma and flavour does not refer to a specific fruit but is the sum of the different fruits that were associated with the chocolates such as dried raisin, coconut and red berries. The basic tastes sweet, sour and bitter were also included in the list. Salt was not included as it is not an ingredient for chocolate and therefore not relevant for the evaluation of chocolate samples. In total there are 28, 32 and 28 attributes for respectively white, milk and dark chocolate.

Chapter 2: Sensory characterization of commercial chocolates and the development of a chocolate sensory wheel and lexicon

Table 2. 2: List of preliminary descriptive terms generated during focus groups for all chocolate samples (n=108)

<i>Appearance</i>				<i>Aroma</i>				<i>Flavour</i>			
Colour	White	Milk	Dark	Fruit	White	Milk	Dark	Fruit	White	Milk	Dark
Colour difference	38	45	41	Dried raisin	10	9	7	Raisin	/	/	2
Gloss	36	27	36	Tropical fruit	1	/	3	Red Berry	1	2	2
Fat bloom	1	3	1	Dried banana	4	/	1	Banana	7	1	1
Colour evenness	2	4	3	Prunes	/	3	1	Coconut	/	17	1
Surface				Cherry	/	/	1	Other fruit	5	14	11
Rough	18	18	20	Red berry	/	15	13	Sweet			
Hardness	3	6	4	Coconut	/	14	3	Jam	1	/	/
Fatty feeling	2	1	1	Floral				Honey			9
Air bubbles	3	4	2	Jasmine	3	3	2	Sugar	2	1	2
Flakiness	4	5	4	Roses	2	/	/	Caramel	5	22	2
Shape				Orange blossom	1	3	4	Liquorice		/	/
Thickness	23	21	22	Vanilla	44	9	2	Ginger cookie	1	/	/
Shape	23	19	22	Sweet				Marzipan		/	13
Cross section				Caramel	8	27	3	Vegetable			
Graininess	6	11	10	Burnt sugar	5	2	/	Mint	/	1	2
Layered	5	7	5	Marzipan	/	4	4	Olives	/	1	/
<i>Texture</i>				Jam	/	/	5	Tea		1	/
Mouthfeel				Honey	10	5	1	Hay	/	3	5
Graininess	22	22	23	Beeswax	1	2	4	Floral			
Dryness	6	9	12	Liquorice	/	11	5	Rose	/	1	/
Coating	6	7	2	Vanilla cookie	/	/	2	Vanilla	32	6	3
Stickiness	28	24	23	Earthy				Other flowers	/	/	1
Creaminess	19	16	3	Nuts	1	16	6	Alcohol			
Roughness	3	4	3	Leather	2	3	6	Alcohol	/	2	4
Fattiness	3	4	4	Coffee	2	15	19	Earthy			
Bite				Cocoa	1	29	39	Nuts	1	14	3
Hardness	36	34	37	Wood	1	18	19	Coffee	/	8	18
Snap	24	26	27	Roasted almonds	/	4	6	Cocoa	/	14	22
Even bite	1	1	1	Tobacco	/	7	11	Tobacco	/	4	8
Crunchy	3	4	4	Mushroom	/	2	/	Wood	/	12	7
Crumbly	8	9	9	Moss	/	1	7	Mushroom	/	/	1
Melting				Fresh grass	/	1	6	Moss	/	1	2
Melting behaviour	38	38	32	Smoke	/	2	2	Fresh grass	/	2	1
Cohesion	6	6	6	Earth	/	1	14	Earth	/	/	12
Shape				Forest	/	1	1	Forest	/	/	1
Thickness	8	7	7	Manure	/	/	1	Spicy			
				Vegetable				Cinnamon	/	/	1
				Tea	/	3	6	Dairy			
				Hay	/	4	8	Cream	5	5	1
				Dairy				Milk	14	10	0
				Cream/milk	33	14	2	Butter	29	7	1
				Butter	36	4	1	Other			
				Spicy				Insects	/	1	2
				Cinnamon	/	1	/	Plastic	/	1	1
				Bakery				Cough syrup	/	/	3
				Flour	1	1	/	Aftertaste	13	12	12
				Bread / Toast	/	3	/				
				Other							
				Plastic	/	4	/				
				Insects	/	/	8				

Table 2. 3: Selected sensory attributes for quantitative descriptive analysis with trained panel

Appearance	Aroma			Texture	Flavour		
	White	Milk	Dark		White	Milk	Dark
Colour	Fruit	Fruit	Fruit	Graininess	Fruit	Fruit	Fruit
Gloss	Vanilla	Vanilla	Nuts	Dryness	Honey	Caramel	Coffee
Graininess	Caramel	Caramel	Coffee	Stickiness	Caramel	Marzipan	Cocoa
	Burnt sugar	Honey	Cocoa	Creaminess	Vanilla	Nuts	Tobacco
	Honey	Nuts	Wood	Hardness	Milk	Cocoa	Wood
	Cream/milk	Coffee	Earth	Snap	Butter	Wood	Earth
	Butter	Cocoa	Vegetable	Melting rate	Sweet	Milk	Sweet
		Wood		Thickness	Sour	Sweet	Sour
		Tobacco			Bitter	Sour	Bitter
		Cream/milk			Aftertaste	Bitter	Aftertaste
					Aftertaste	Aftertaste	Aftertaste

2.3.2. Sensory profiles of commercial white, milk and dark chocolate

Before putting together the sensory wheel, it is important to indicate that it is possible to differentiate commercial samples based on the gathered attributes. As different attributes are used for the aroma and the flavour description of the types of chocolate, the results of the sensory profiles of white, milk and dark chocolates are given separately. A simple and convenient way of visualizing differences in sensory profiles between samples is by means of a spider plot. The attribute intensities for the nine chocolate samples with distinctly different sensory characteristics are shown in Figure 2. 1. Only the significant differences are shown in the spider plots.



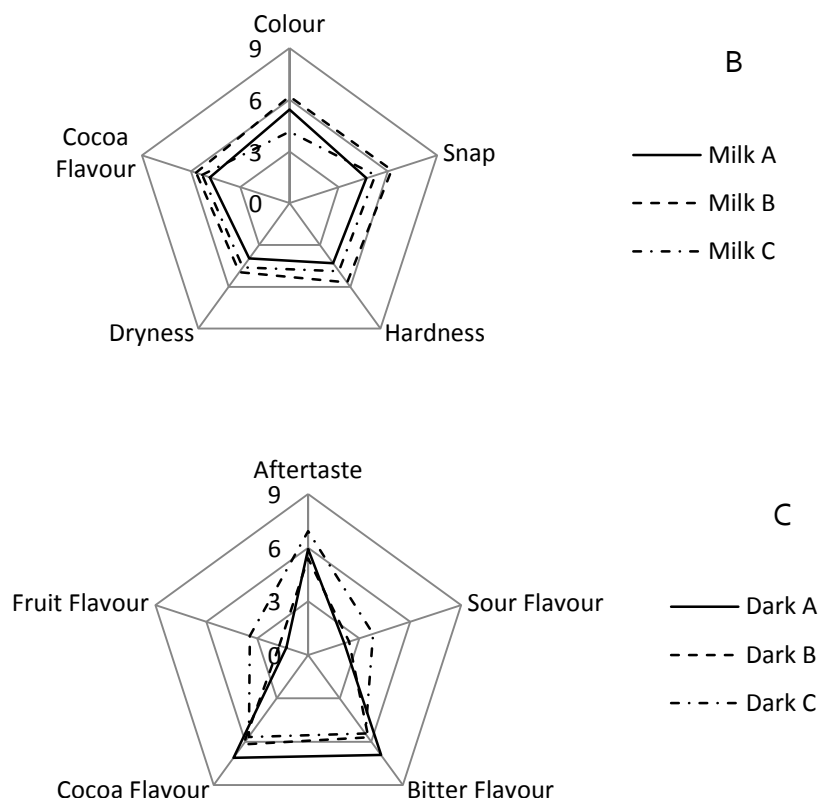


Figure 2. 1: Significant differences among the A) white chocolate samples, B) milk chocolate samples and C) dark chocolate samples

2.3.2.1. White chocolate

For appearance, a significant difference was found for colour and graininess. White A was evaluated as slightly more yellow than white B and C. White B has the least grainy cross section. No significant difference was found for gloss of the chocolates. For texture, significant differences were found for hardness and creaminess. White B is found to be harder than white A and C. White C had a significant creamier feeling in the mouth than the other two samples. The vanilla and milk/cream aroma is more profound in white C compared to white A and B. Butter and sugar aroma were also perceived as present in the white chocolates but no significant differences were observed. The most differences were found for flavour. White C was found to be sweeter than white A and B. There is a higher sour taste in white A than in white B and C. Similar to the aroma, the vanilla and milk/cream flavour is more pronounced in white C. Although butter and caramel were present in the three samples, no significant difference was found.

2.3.2.2. Milk chocolate

Only five significant differences were found for the milk chocolates. For appearance, the colour was significantly different between the three samples. No significant differences were found for the graininess of the cross section and the gloss of the milk chocolates. No significant differences were found for the aroma attributes. The intensity of the cocoa aroma

was high in all the samples but also milk/cream, caramel and vanilla aroma were present in all the samples. The most significant differences were found in the texture of the chocolates. Milk B was found to be the hardest and with the highest snap whereas milk A was perceived as the softest with the lowest snap. After consumption, the dryness in mouth was highest for milk B in comparison to milk C and A. Although no significant difference was found, the time-intensity test shows that milk A and C melts faster than milk B. The milk chocolates tasted sweet with a little bitter touch, but no significant differences were found for the basic tastes. The flavours that were most perceived were cocoa, milk/cream and caramel. For cocoa flavour a significant difference was found for milk B on the one hand and milk C and A on the other hand.

2.3.2.3. *Dark chocolate*

The trained panel indicated that no significant difference is present in the appearance, aroma and texture of the three dark chocolates. They did indicate that the cocoa aroma was dominating the aroma of the dark chocolate although hints of coffee, tobacco, plants and fruit were perceived. All the significant differences between the samples were found in the taste and flavour of the chocolates. The bitter taste was found to be most present in dark A whereas dark C and B, were not significantly different in bitter taste. Dark C has a significantly higher sour taste than dark A and B. Other significant differences were found for fruit and cocoa flavour. The fruity flavour of dark C was higher than for dark A and B. The cocoa flavour is more pronounced for dark A and the least pronounced for dark C. Finally the aftertaste after swallowing the sampled was higher for dark C than dark A and B.

These results indicate that difference among the white chocolate are spread over several sensory characteristics of appearance, texture, aroma and flavour. For milk chocolate, the differences are limited to texture and flavour although colour can also play a role in the differences between milk chocolates. For dark chocolate, differentiation is only made on the flavour.

2.3.2.4. *Differences between the three types of chocolate*

As very little significant differences were found within each group of chocolate, it is interesting to look at the differences between the three types of chocolate. Overall mean scores for the three types are calculated based on the evaluations of the trained panel. Colour is not included as the trained panel evaluated each type of chocolate on a different colour scale relevant to the specific chocolate. Also melting rate and thickness were not included in the list. Melting rate measured different from the other attributes. Here the trained panel had to mark the amount of solid chocolate on a graph which resulted in a slope. Therefore these results could not be taken into account when constructing the PCA. Also the thickness was left out as this was different for some pieces and could be standardized.

Table 2. 4 shows that for all attributes on appearance and texture except graininess and stickiness, the chocolates are different from each other. It also shows that dark chocolate is

very different from white and milk chocolate for these sensory attributes. As the three types are characterized by different aromas and flavours, that makes it difficult to compare the three types of chocolate for these sensory attributes.

Table 2. 4: Mean values of the sensory attributes for the three types of chocolate

		White	Milk	Dark
Appearance	Gloss	3.7 ^a	3.2 ^a	4.3 ^b
	Graininess	3.2 ^a	4.7 ^b	3.6 ^{a,b}
Texture	Snap	5.9 ^{a,b}	5.4 ^a	7.1 ^b
	Hardness	5.6 ^{a,b}	5.0 ^a	6.6 ^b
Aroma	Creaminess	4.5 ^a	5.0 ^a	3.3 ^b
	Graininess	2.7 ^a	2.9 ^a	2.6 ^a
	Dryness	3.6 ^a	4.5 ^b	4.9 ^b
	Stickiness	4.3 ^a	4.2 ^a	4.0 ^a
	Aftertaste	4.7 ^a	4.8 ^a	6.1 ^b
	Vanilla	4.5 ^a	3.2 ^a	/
	Butter	5.1 ^a	/	/
	Cream/milk	5.2 ^a	3.9 ^b	/
	Fruit	1.5 ^a	1.3 ^a	1.6 ^a
	Honey	1.5 ^a	1.3 ^a	/
Flavour	Caramel	1.7 ^a	2.5 ^b	/
	Burnt sugar	2.2 ^a	/	/
	Cocoa	/	5.1 ^a	5.7 ^a
	Wood	/	1.5 ^a	1.7 ^a
	Coffee	/	1.6 ^a	2.1 ^a
	Earth	/	/	1.7 ^a
	Vegetable	/	/	1.7 ^a
	Nuts	/	1.7 ^a	1.4 ^a
	Tobacco	/	1.4 ^a	2.2 ^b
	Vanilla	4.7 ^a	/	/
	Butter	5.1 ^a	/	/
	Milk/Cream	5.3 ^a	4.3 ^a	/
	Caramel	3.0 ^a	3.2 ^a	/
	Fruit	1.9 ^a	1.4 ^a	2.1 ^a
	Honey	1.8 ^a	/	/
	Cocoa	/	5.3 ^a	6.3 ^a
	Nuts	/	1.8 ^a	/
	Wood	/	1.3 ^a	1.5 ^a
	Marzipan	/	1.1 ^a	/
	Coffee	/	/	2.2 ^a
	Tobacco	/	/	2.0 ^a
	Earth	/	/	1.5 ^a
	Sweet	5.5 ^a	5.7 ^a	3.8 ^b
	Sour	2.2 ^a	1.5 ^a	2.8 ^a
	Bitter	1.6 ^a	2.0 ^a	6.0 ^b

^{a,b,c} presents significant differences between mean values within the same row

Standardized PCA plots using the correlation matrix are commonly used in sensory analysis to visualize the relation between attributes as well as between samples based on the variation in the samples... Although the variation between the three types of chocolate is rather large (white, milk and dark chocolate), a total of nine samples (three for each group) might be too low to fully explain the positioning of the samples in the plot. The normal ratio is 2:1 (objects to variables) when looking at specific products. This guideline is often infringed in sensory analysis when PCA is applied to averaged data on a small number of products examined on any variables in the form of sensory attributes. However, the interpretation will focus on the relation between the sensory attributes than on the differences between the samples. Figure 2. 2 shows four different PCA plots for appearance, aroma, texture and taste/flavour.

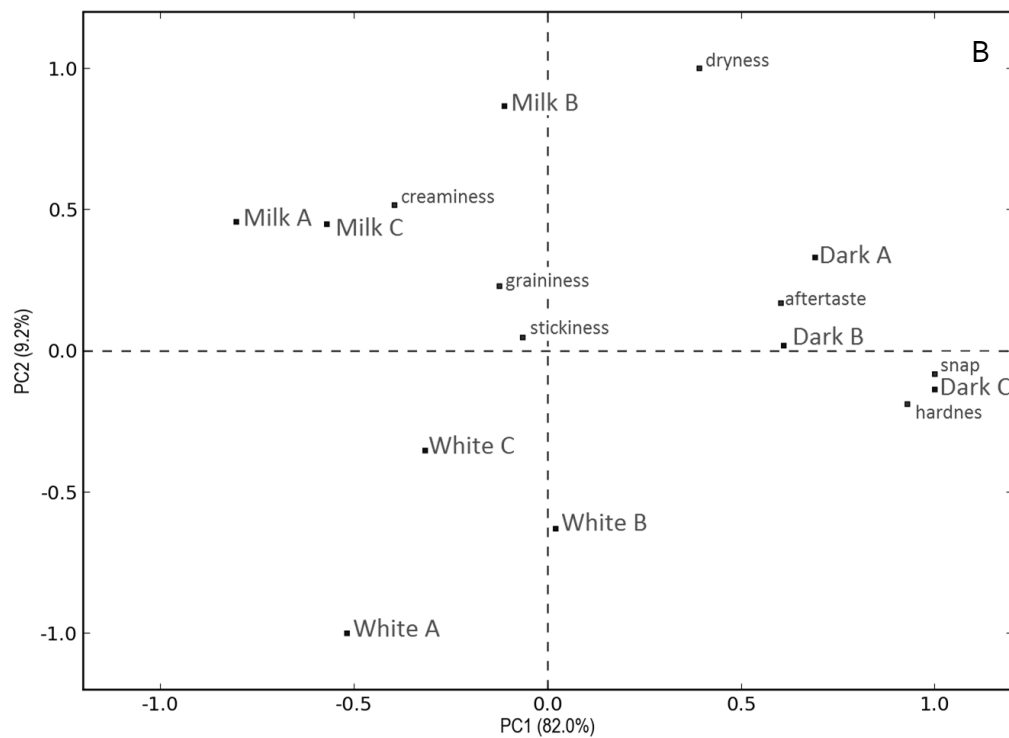
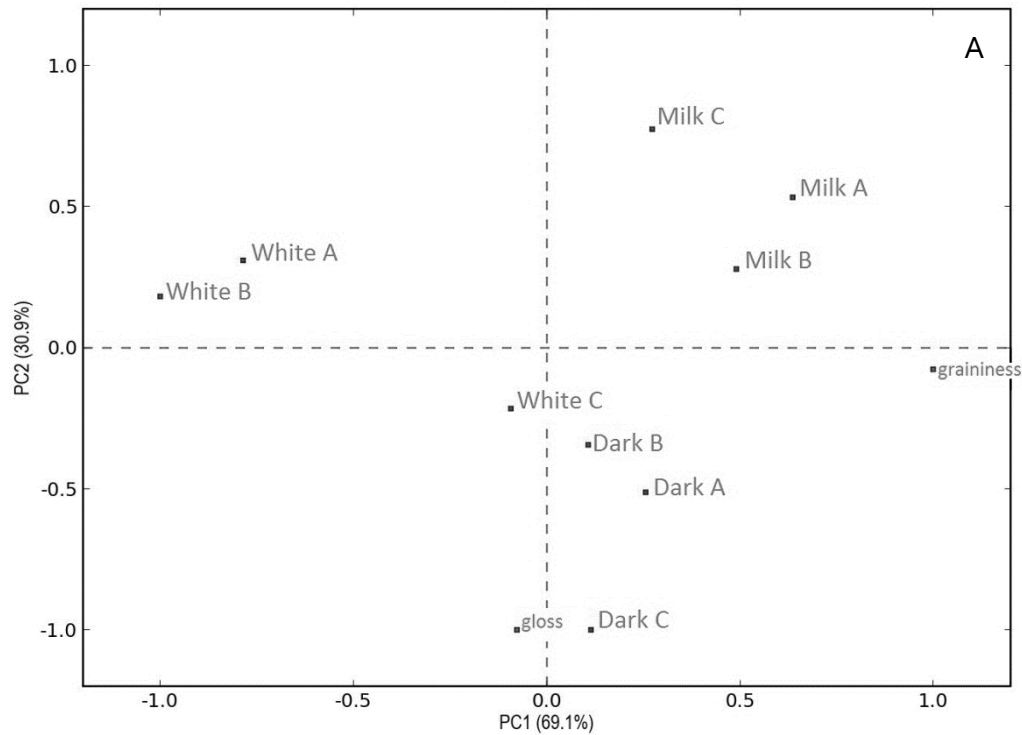
The PCA loadings plot of appearance (Figure 2. 2) indicates that the two appearance attributes, gloss and graininess are not correlated to each other. The plot shows according to PC1 the gloss is more related to white C and all the dark chocolates. Graininess is correlated to milk and dark chocolates and not to white chocolates.

In the PCA loadings plot of the texture attribute (Figure 2. 2 b) aftertaste was taken into account as aftertaste was evaluated after the texture attributes and could have been influenced by the texture characteristics such as stickiness or graininess. Moreover, the aim of the flavour PCA-plot was to give an overview of all the relevant tastes and flavours thus excluding aftertaste. As hardness and snap are positioned close to each other, it can be assumed that these attributes are closely related. As snap is defined as the noise and force with which the sample breaks or fractures (Table 3. 12), it is natural that there is a close relation to hardness. Further, graininess and stickiness also appear to be correlated. These two attributes are centred in between the three groups of chocolate which corresponds to the results in Table 2. 4. The positioning of the attributes towards the samples shows that hardness and snap are more indicative for dark chocolate and creaminess more for milk chocolates.

Figure 2. 2 c shows all the aromas used for the evaluation of the three chocolates. The PCA shows that milk/cream aroma and vanilla aroma are correlated. It is similar for vegetable and earth or for wood and coffee. Tobacco and nuts are also two aromas which are depicted close to wood and coffee. On the other hand, cocoa and butter are positioned in opposite corner of the sensory spectrum as presented in this PCA. The positioning of the aromas also explains the positioning of the samples. The white chocolates have a butter and sugar aroma whereas milk/cream, vanilla, honey aroma are representative for both white and milk chocolates. Caramel aroma is only related to milk chocolate. Milk and dark chocolate have the nutty, woody, tobacco, coffee and cocoa aroma in common. Aromas of plants and earth are only characteristic for dark chocolates.

The visual relationship between the basic tastes and flavours are presented in Figure 2. 2 d. Similar to the PCA loadings plot for aroma, the three types of chocolate are grouped together with little difference among the samples within one type of chocolate. Again some flavours

or tastes are positioned close to each other. Butter and vanilla seem to be related, similar to coffee, tobacco, earth, sour and even fruit. The PCA also shows that the flavour profile for the three different types is clearly different which corresponds to the findings from Table 2. 4.



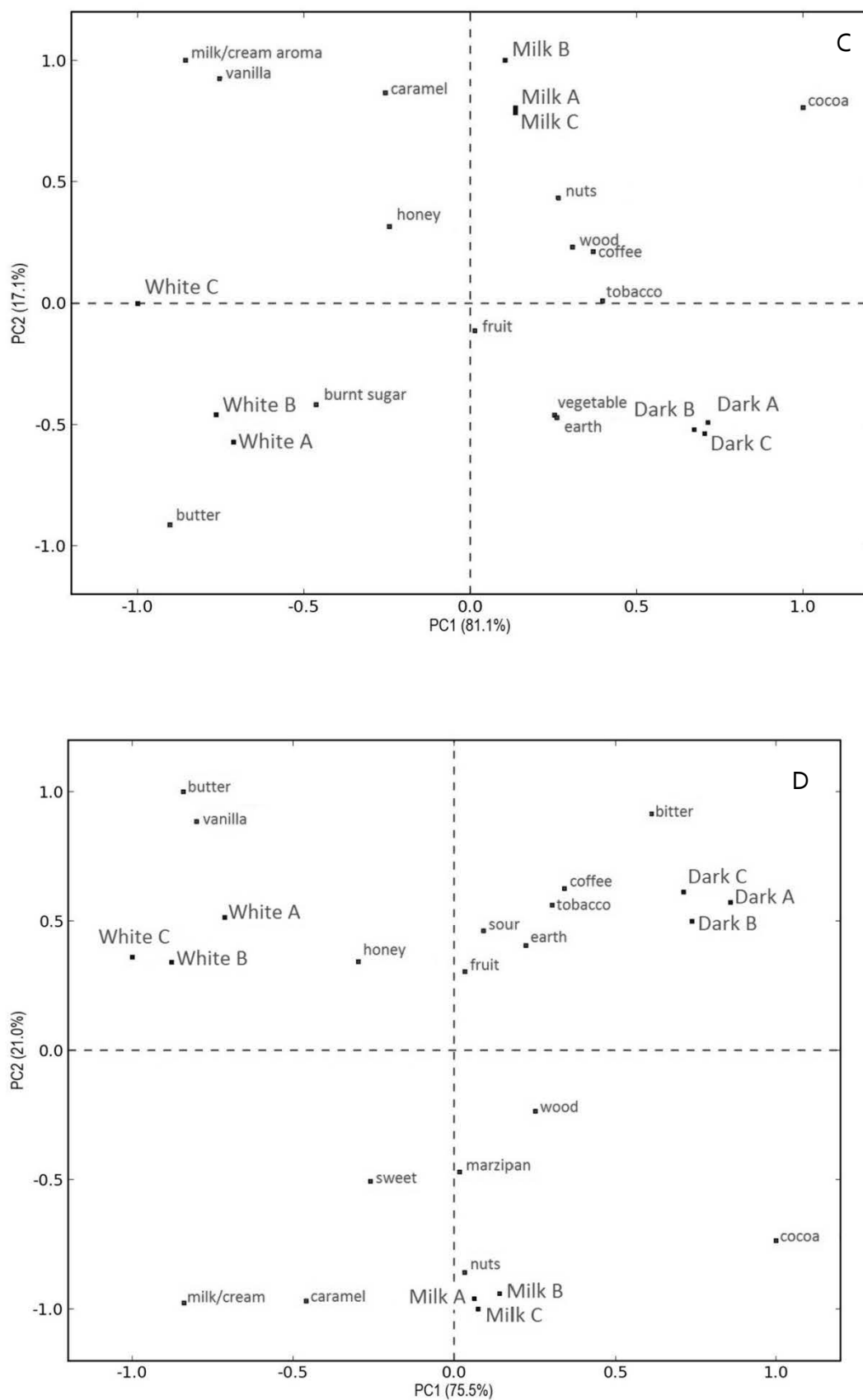


Figure 2. 2: PCA analysis of the significant sensory attributes for the three types of chocolate on A) Appearance, B) Texture, C) Aroma and D) Flavour

2.3.3. Instrumental analyses of commercial white, milk and dark chocolate

2.3.3.1. Colour

The means of the parameters L^* , C^* , h° are presented in Table 2. 5. Significant differences are detected among all white chocolate samples for the L^* and C^* , but not for h° . This indicates that the chocolates have different places in the 3D CIELAB-colour model. White C has a lighter colour than the other two samples as indicated by the high L^* - value. The C^* - value is highest for the white A which indicates that the dominant colour is more pronounced for this sample.

For milk chocolate, Table 2. 5 shows that the brightness of milk B is significantly different from the other chocolate samples. For the C^* and h° value, all three samples are significantly different which indicates that the overall colour of the three samples is different. Finally for the dark chocolate samples, the colour difference between dark B and dark C is rather small as the L^* and h° value are not significantly different. Dark A has a lower brightness, a higher chroma and colour saturation compared to dark B and dark C. Therefore, the distance between dark A and the other two samples in the CIELAB 3D model is large.

Naturally the colour of white, milk and dark chocolate are significantly different due to the ingredients and more specifically the amount of cocoa mass.

Table 2. 5: Mean scores and standard deviation of colour parameters (L^* , C^* , h°) for white, milk and dark chocolate (n=10)

	L^*	C^*	h°
White A	83.0±0.2 ^a	28.9±0.2 ^a	-1.6±0.0 ^a
White B	84.2±0.3 ^b	26.8±0.5 ^b	-0.9±1.2 ^a
White C	84.7±0.9 ^c	25.7±0.4 ^c	-1.5±0.0 ^a
Milk A	36.6±0.4 ^a	16.4±0.2 ^a	0.9±0.0 ^a
Milk B	33.1±0.6 ^b	14.2±0.8 ^b	0.8±0.0 ^b
Milk C	36.8±0.5 ^a	16.9±0.1 ^c	0.9±0.0 ^c
Dark A	25.1±0.2 ^a	5.8±0.2 ^a	0.7±0.0 ^a
Dark B	26.2±0.2 ^b	6.1±0.1 ^b	0.6±0.0 ^b
Dark C	26.1±0.4 ^b	6.7±0.1 ^c	0.6±0.0 ^b

^{a,b,c} presents significant differences between mean values within the same column for every type of chocolate (white, milk and dark chocolate)

2.3.3.2. Hardness

Figure 2. 3 shows that the hardness is significantly different for all the white chocolates. White A is the softest and white C is the hardest. For the milk chocolates, milk B is significantly harder than the other two samples. The hardness for the three dark chocolates is also significantly different with dark B the softest, then dark A and dark C as the hardest.

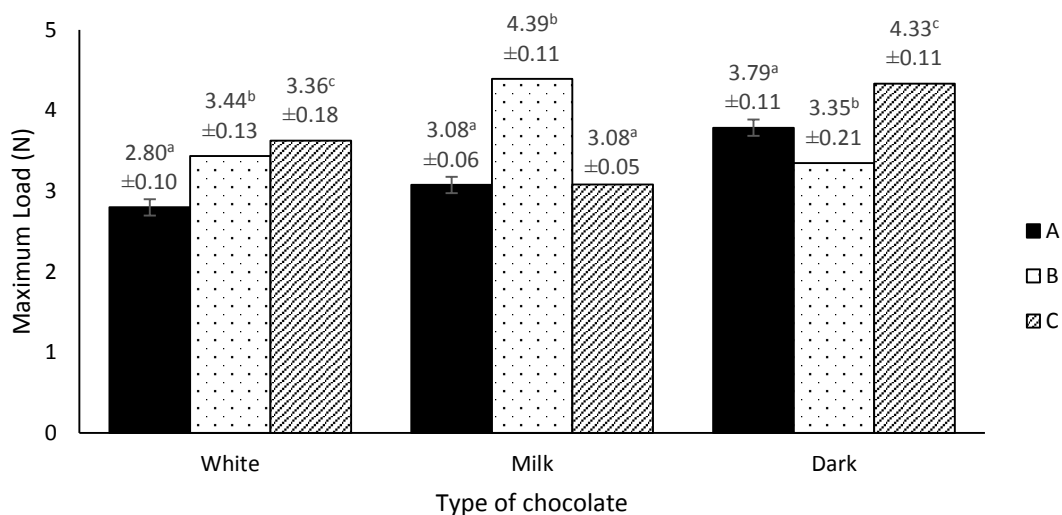


Figure 2. 3: Results of the hardness measurement for white, milk and dark chocolate (n=10)

^{a,b,c} presents significant differences between mean values for every type of chocolate (white, milk and dark chocolate) on hardness

2.3.3.3. Solid fat content (SFC)

Figure 2. 4 shows the SFC profile of all three types of chocolate. For the white chocolates, the results indicate that white A and white C have a similar solid fat profile. The SFC of white B shows a flatter course of the curve until 25°C, followed by a more steep decrease between 25°C and 35°C. For none of the samples, solid fat was detected above body temperature. The SFC-value at 20°C is an indication for the hardness of the chocolate (Full et al., 1996). The solid fat for white B (50.3%) is higher than the solid fat of white A (45.0%) and white C (43.5%) which indicates that white B is the hardest chocolate. There is no significant difference in the heat resistance (SFC between 25°C – 30°C) of the three chocolate samples.

Figure 2. 4 indicates that milk B has a different melting profile than milk A and milk C as these two SFC are overlapping. The solid fat of milk B is higher at every temperature measurements were done. All chocolates are melted at body temperature. Milk B is found to be harder than milk A and C as the SFC at 20°C is 53.1% for milk B and 46.3% for the other two. Although no significant difference is found, the heat resistance of milk B is the highest.

For the dark chocolate, three different melting profiles are found. Dark C is the slowest melting chocolate whereas dark A melts down the fastest. Again all chocolates have 0.0% solid fat at body temperature. Based on the SFC at 20°C, dark C (75.6%) is found to be the hardest chocolates followed by dark B (71.9%) and dark A (67.9%).

For the SFC curves, it can be concluded that for all measurements, the dark chocolates have a higher solid fat content whereas no difference is found between white and milk chocolate. This shows that dark chocolate melts at a higher temperature, and is thus harder than white and milk chocolate.

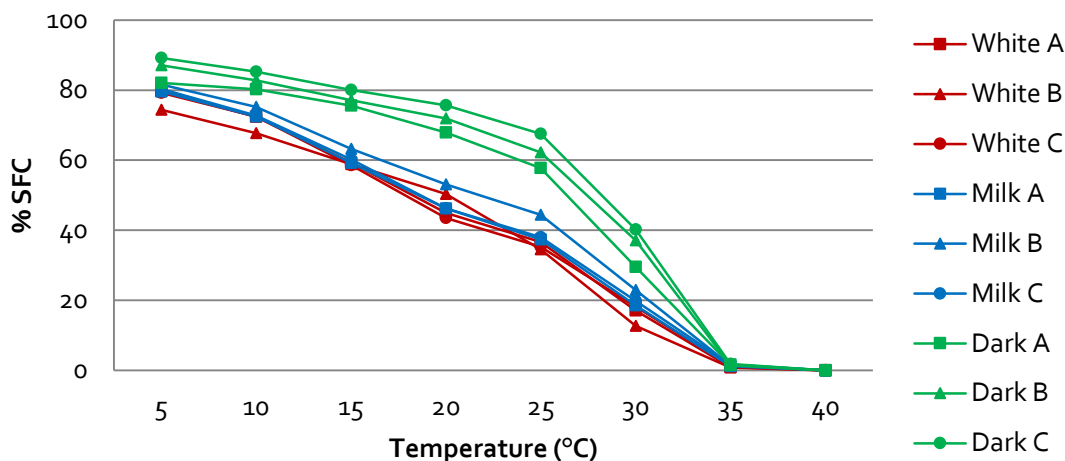


Figure 2. 4: SFC curves in function of temperature (°C) for white, milk and dark chocolate (n=3)

2.3.3.4. Melting profile

The DSC curves of the white chocolates are very similar. The only parameter that shows a significant difference is the melting range (Table 2. 6). White C will melt at a lower temperature than white A and white B. This is probably due to the higher percentage of milk fat in white C. The other parameters are not significantly different. Due to the high amount of milk fat, the white chocolate will start to melt at a lower temperature. The large peak width can be explained by presence of a mixture of fats rather than the pure polymorph fat crystals in chocolate.

The white and milk chocolate show no significant difference for the DSC parameters. These chocolates have a low onset temperature, a low melting range, need less enthalpy to melt and have broader peak width in comparison to dark chocolates.

Table 2. 6: Mean values and standard deviation of DSC parameters (Tonset, Peak surface, Final melting point, Peak width) for white, milk and dark chocolates (n=3)

	T onset (°C)	Peak surface (J/g)	Final melting point (°C)	Peak width (°C)
White A	28.7 ± 1.8 ^a	31.5 ± 1.4 ^a	33.2 ± 0.1 ^a	4.6 ± 1.0 ^a
White B	26.4 ± 0.2 ^a	28.5 ± 0.5 ^a	32.9 ± 0.2 ^a	5.4 ± 0.2 ^a
White C	28.0 ± 1.8 ^a	26.5 ± 2.5 ^a	32.3 ± 0.1 ^b	4.2 ± 0.5 ^a
Milk A	28.0 ± 1.5 ^a	27.2 ± 1.0 ^a	32.6 ± 0.2 ^a	4.4 ± 0.5 ^a
Milk B	26.5 ± 0.4 ^a	27.5 ± 1.2 ^a	32.8 ± 0.2 ^a	5.1 ± 0.3 ^a
Milk C	25.9 ± 0.1 ^a	28.4 ± 1.3 ^a	32.5 ± 0.1 ^a	4.8 ± 0.1 ^a
Dark A	32.6 ± 0.5 ^a	49.7 ± 2.0 ^a	34.4 ± 0.2 ^a	3.2 ± 0.7 ^a
Dark B	32.0 ± 0.0 ^a	44.6 ± 4.8 ^a	34.7 ± 0.2 ^a	3.8 ± 0.3 ^a
Dark C	31.5 ± 0.0 ^a	51.1 ± 2.7 ^a	33.8 ± 0.1 ^a	3.3 ± 0.6 ^a

^{a,b,c} presents significant differences between mean values within the same column for every type of chocolate (white, milk and dark chocolate)

For the milk chocolates, no significant difference is found among the samples. Therefore, it can be concluded that the amount and the polymorphs in the different milk chocolates are similar which indicates that they contain similar fat compositions.

No significant differences are found for the dark chocolates. The onset temperature ($\pm 32.0^{\circ}\text{C}$), the melting range ($\pm 34.3^{\circ}\text{C}$) and the narrow peak width shows that for every dark chocolate, the fat composition is mostly cocoa butter which is crystallised in the stable β -polymorph.

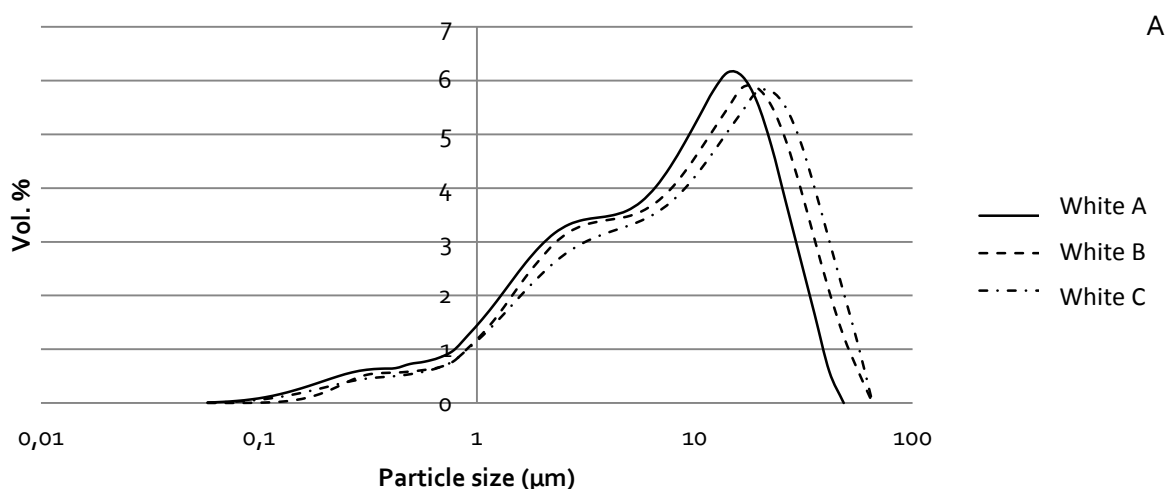
2.3.3.5. Particle size distribution

The PSD-curves are shown in Figure 2. 5. For white chocolate, the PSD-curves show a similar course. The most important parameter is D₉₀ percentile. The diameter of 90% of the amount of total solid particles is equal or lower than the D₉₀ -value. White A has the lowest mean diameter (9.4 μm) and 90% of all particles have a diameter smaller than 21.5 μm . White B and white C are composed of larger particles with D₉₀ -value of respectively 26.8 μm and 30.7 μm .

The curves of the milk chocolate are significantly different. The mean particle size of milk C (11.7 μm) is larger than milk B (9.5 μm) and milk A (8.9 μm). The D₉₀ value gives that 90% of the diameter of the particles is milk A, milk B and milk C are lower than respectively 22.3 μm , 24.4 μm and 30.0 μm .

Significant differences are found in the PSD of the dark chocolates. Dark C has a significantly smaller mean diameter (8.7 μm) than dark A (9.5 μm) and dark B (9.7 μm). The distribution of the particle size is similar for the three dark chocolates. The D₉₀ value for dark A, dark B and dark C are respectively 21.4 μm , 21.8 μm and 19.3 μm .

The results of the PSD indicates that the dark chocolates are composed of the smallest particles. Again, no significant difference is found between the mean particle size of the white and milk chocolates.



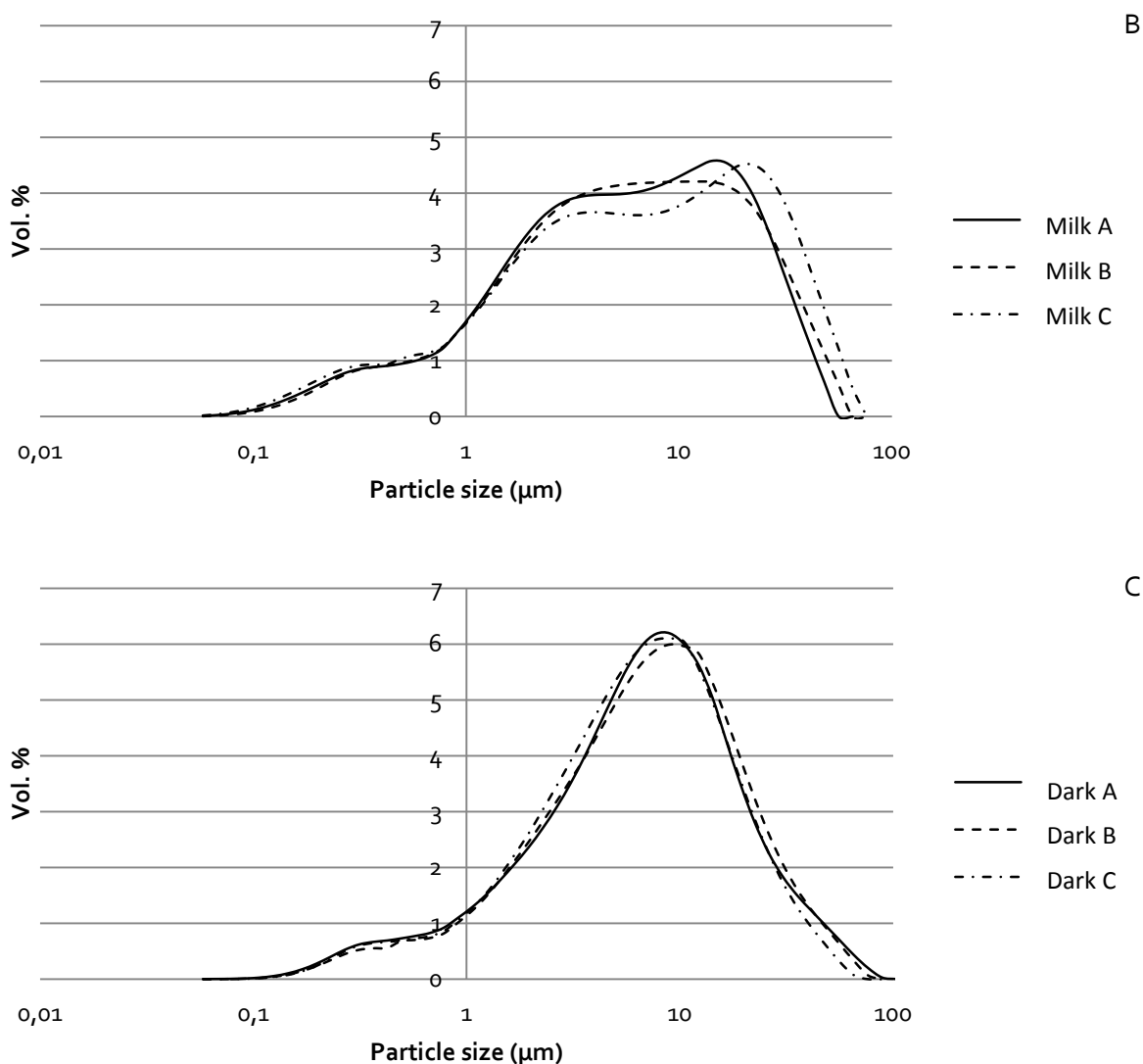


Figure 2. 5: Particle size distribution for A) White chocolate, B) Milk chocolate and C) Dark chocolate (n=5)

2.3.4. Correlation between sensory and instrumental analysis

Figure 2. 6 presents the PCA loadings of the sensory characteristics that can be corresponded with the instrumental parameters. Both attributes and parameters are included in the PCA plot. Therefore, SFC was not included as no real sensory equivalent is available.

Figure 2. 6 shows that the instrumentally measured hardness is highly correlated with gloss but sensory hardness and snap are positioned further away. Particle size measurements were however not correlated to graininess of chocolate. This plot indicates that snap and hardness are closely related just as graininess and stickiness.

Snap, hardness, gloss and dryness are sensory attributes that are more related to dark chocolates whereas creaminess and grainy texture and appearance are sensory attributes that are noticeable in white and milk chocolates.

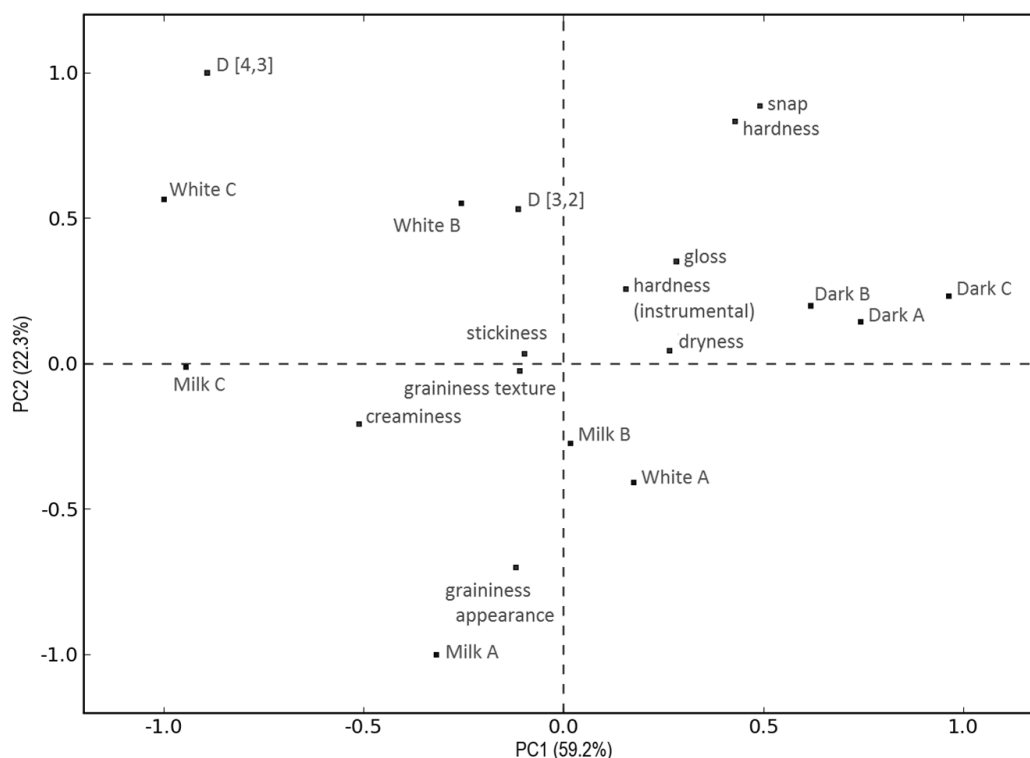


Figure 2. 6: PCA analysis of the relevant sensory attributes and the corresponding instrumental parameters for the three types of chocolate.

2.3.5. The sensory wheel

The sensory profiling of these 9 commercial samples indicated that the commercial samples could be differentiated on both the sensory attributes as the instrumental analyses. Therefore, it is clear that the selected sensory attributes can be used to differentiate chocolate samples. These collected attributes from Table 2. 3 were used to assemble the sensory wheel for chocolate.

Based on the frequency of quotation in the focus groups, 8 appearance, 22 aroma, 11 texture and 18 flavour attributes were selected from the list of descriptive terms generated by the attendees in the focus groups. The basic flavours sweet, bitter and sour were added to these attributes. The 62 terms were depicted in a two-tiered wheel (Figure 2. 7).

It was decided to work with a sensory wheel as this is easy to use for consumers. The descriptors from the inner tier are the primary descriptors that group a certain type of attributes, while the more specific attributes are found in the outer tier.

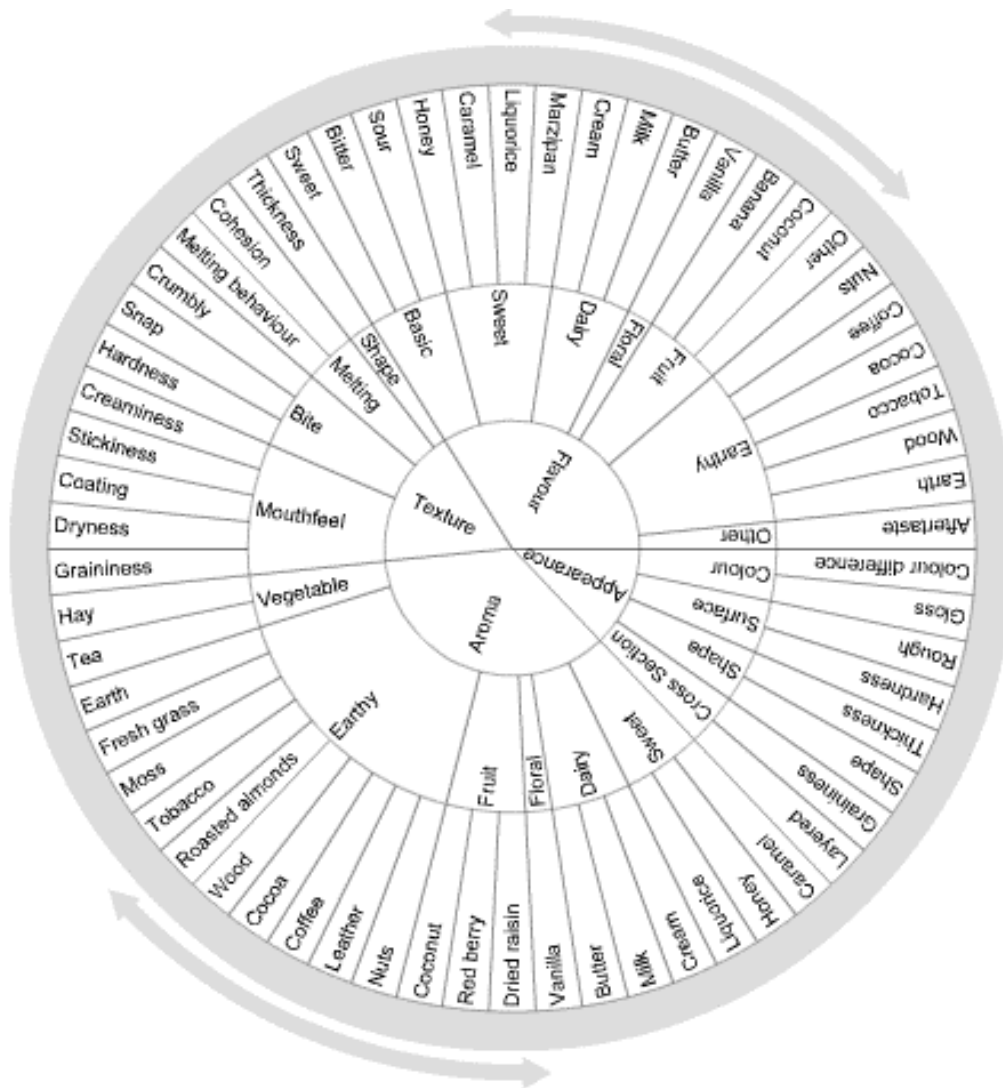


Figure 2. 7: Chocolate sensory wheel

2.4. Discussion

2.4.1. Sensory wheel

In this study, focus groups were organised to collect information on the describing, preferred and differentiating sensory attributes of white, milk and dark chocolate. The goal was to identify a broad range of sensory attributes which can be useful to evaluate and characterise all kinds of chocolate products. Because sensory characterisation of chocolates can be used to understand which characteristics are influencing consumers' preference, this can create opportunities for product improvement or product development. These gathered descriptors are presented in sensory wheels.

The largest differences between the three types of chocolate were found for the aroma and flavour descriptors of white, milk and dark chocolate. This indicates that flavour and aroma characteristics are certainly determined by the composition of the ingredients and the types of cocoa beans. The more cocoa mass is added to chocolate, the more extensive the aroma and flavour spectrum of the chocolates becomes. Table 2.1 indicates that there are a lot more flavours than the ones that are taken into account in the sensory wheel. Some of these flavours rarely occur in standard chocolates but are more present in origin chocolates. Some genotypes of cocoa beans are specifically selected and used for their flavour potential.

For appearance and texture, similar attributes are pointed out as being important for discrimination of the three types of chocolates. However, other standards are set for these attributes according to the type of chocolate. For example hardness and snap need to be different in white, milk and dark chocolate. These descriptors for appearance and texture are related to the production parameters.

Table 2. 2 can be of great value for product developers as it indicates the number of times a sensory characteristic was indicated to be important for a consumer. First, it shows large differences between white, milk and dark chocolate specifically for aroma and flavour. Second, it also shows similarities for appearance and texture. The consumers clearly indicated that similar attributes of appearance and texture are important in white, milk and dark chocolate. The difference between the types of chocolates is thus not related to the presence of these attributes, as with aroma and flavour, but to the intensity of these parameters (e.g. different hardness for white, milk and dark chocolate).

Despite the effort of the manufacturers to create unique products, consumers appear to be very limited in their vocabulary to describe the sensory properties of chocolate (Thamke et al., 2009). This is also consistent with previous descriptive studies in dark and milk chocolates, which showed that only a few aroma descriptors were indicated as being important. Those studies also revealed that taste and mouth feel were the most significant sensory categories for describing a chocolate product (Thamke et al., 2009, Dürschmid et al., 2006).

It should be noted that this study was only a first attempt at developing a complete chocolate sensory wheel. It can be expected that certain modifications have to be made over time as the wheel is presented to and used by the chocolate industry. Previous examples, such as the wine aroma wheel developed by Noble et al. (1984) was modified after having collected constructive suggestions from the industry (Noble et al., 1987). Some attributes were in that study removed from the wheel while others were added. Moreover, the reference standards were provided for each of the terms and the order of the attributes was altered. Koch et al. (2012) anticipates that similar alterations will be necessary for the sensory wheel for rooibos infusions. Therefore, the complete sensory chocolate wheel will be improved and refined in the future due to feedback from the industry and other researchers.

2.4.2. Sensory profiles of the white, milk and dark chocolate

Only a few significant differences are found among the chocolate samples within each type of chocolate.

The comparison between the types of chocolate can indicate which attributes are typical for white, milk and dark chocolate. For dark chocolate, the high gloss, snap, hardness, and aftertaste are the most important attributes. Dryness in mouth is less pronounced than the former attributes but still more characteristic for dark chocolate than other chocolates. The creaminess is important for milk chocolate.

PCA plots can also be used to indicate whether certain attributes are redundant and may be reduced to a simplified set of terms to prevent different attributes from being used to describe the identical sensory characteristic (Naes et al., 2010a). They can also demonstrate whether correlations exist between an aroma and flavour attribute that has been analysed by nose and by mouth. Most of these attributes such as milk/cream, caramel, nuts, cocoa, tobacco, fruity, honey, earth were closely associated with one another, indicating that these notes were perceived similarly on the nose as well as the palate with the same intensity. Therefore it is possible to perform only aroma or flavour analysis. Future research could combine this analysis from a trained panel with instrumental aroma or flavour analysis. This was not included in this research due to limited resources.

2.4.3. Instrumental analyses of white, milk and dark chocolate

The white chocolates are significantly different in colour. The composition and amount of ingredients used could explain these differences. However, no exact percentages are known for the ingredients in the commercial samples which makes it impossible to link these results. White C has the highest hardness value. Normally, the chocolate with the smallest particle size should be the hardest chocolate due to the high interparticle interaction (Afoakwa et al., 2008c). However, this is not confirmed in these results. Therefore, it can be hypothesized that the fat content is most important for the hardness of white chocolate. Lecithin is also an important factor in defining the hardness of chocolate (Afoakwa et al., 2008b). However, no information is known on the lecithin percentage in the commercial samples.

For milk chocolate, the relation between hardness, the SFC at 20°C and total fat content is clear. Milk B is found to be the hardest chocolate, has the highest SFC (20°C) value and the lowest percentage of fat. Similar results are found for dark chocolates.

Full et al. (1996) found a strong correlation between solid fat at 20°C and hardness of chocolate. Based on these findings, the dark chocolate should be the hardest chocolate and no significant differences should be found between milk and white chocolate. Afoakwa et al. (2008c) indicated that hardness of chocolate is dependent on the total fat content and little dependent on particle size. The hardness of chocolate increases if the total fat content decreases and the particle size is lower. For dark A and dark C no percentages of total fat is known but by comparing the total cocoa mass it can be concluded that dark chocolate has a lower fat content than white and milk chocolate. Further the D_{90} -value for dark chocolate is lower than for white and milk chocolate. The results of this study clearly confirm on all the measured parameters that dark chocolate is significantly harder than the other samples.

Comparing the types of chocolates based on the instrumental data gives some more insight in specific characteristics of the three types. The percentage of cocoa and milk particles present in white, milk and dark chocolate are determinants for the position of the chocolates in the CIELAB model. Brightness is strongly correlated to white chocolate.

Particle size is determined by rolling the cocoa mass. The particle size of white A and dark B are almost similar. These commercial chocolates are produced by the same company and therefore it is possible that similar machinery and process conditions are applied which gives the similar particle size for a white and a dark chocolate. The particle size distribution is however similar for all the chocolates that were included in the study. There is clearly a cut-off particle size that the chocolate industry uses which is around 25 μm (Chapter 3).

The fat composition will determine the composition of the DSC-curve and its parameters. When cocoa butter is used in its pure stable polymorphic form, the melting range, the temperature at maximum enthalpy, is expected to be 34-36°C and the curve is composed of small peaks. Further, the onset temperature, temperature at which the chocolate starts to melt will be higher than when a mixture of fats is used. These characteristics will lead to a higher enthalpy to melt down the chocolates. The white and milk chocolates show no differences in DSC-curve or parameters. These chocolates have a lower onset temperature, a lower melting range, need less heat to melt down and have smaller peaks compared to dark chocolate. This is caused by the mixture of fats (cocoa butter and milk fat) that is used (Afoakwa et al., 2007). Cocoa butter is used in pure form in dark chocolate and crystallizes here in the stable β crystals. The dark chocolates have a higher solid fat content at every temperature for which measurements were done. This is in line with the conclusion that dark chocolate melts down at a higher temperature (Afoakwa et al., 2007).

2.4.4. Correlation between sensory and instrumental data

The correlation between the instrumental and sensory analysis is limited as little of the instrumental parameters could be linked to the sensory parameters. However, PCA plots can be used to indicate whether attributes are redundant (Naes et al., 2010a) and this can also be used for replacing instrumental measurements with sensory measurements or vice versa. As shown here hardness, snap or melting rate can be measured by a sensory panel or by instrumental measurements. This decision is up to a producer and is probably dependent on time and money that need to be invested in the different types of measurement.

Although it was not included in the PCA – plot, the melting behaviour of the different types of chocolate was measured through DSC analyses and this indicated that no significant differences were present among the three types of chocolate. This was confirmed by the time intensity tests of the trained panel for the chocolate samples. Although the differences from the sensory evaluation were not significant, the results showed that dark chocolate was melting at a slower rate than the white and milk chocolates. The results of the SFC measurement confirmed this.

This again shows that sensory analysis and instrumental analysis can provide similar information about product differences.

2.5. Conclusion

The most defining descriptors for appearance of chocolate are colour, gloss and smoothness of the surface. Hardness, snap, melting behaviour and graininess are the texture attributes on which the choice of consumers is based. Although these descriptors are used for white, milk and dark chocolate, different standards are set for these attributes for the different types of chocolate. The main differences are found in the aroma and flavour profile.

The sensory wheel can be a valuable tool in the Stage-Gate® method in the very beginning and end of the process. In the discovery stage, it can help together with qualitative research to identify the key sensory aspects that need to be taken into account when producing a new product. As these aspects can be labelled as 'consumer needs', the end-product will need to fulfil these needs. At the launch, this sensory wheel can also be used in the communication for the new product. In a B2B setting, the producer can show its customer on which sensory aspects the new product outranks others. In B2C environment, the wheel can be useful in the promotion of the product.

Perfection is difficult to achieve but all chocolate producers are thriving to produce the product with optimum sensory characteristics for each segment of the market. In order to achieve this, the understanding of consumers, the instrumental evaluation and the evaluation with a sensory trained panel are very important. As a producer, it is important to know which sensory descriptors are important and steering the decision of the consumer to buy, eat and repeat the process. Through focus groups, these descriptors can be identified and an extensive consumer test can indicate the importance and expectations of these attributes. Instrumental analyses help a producer to select the best ingredient and set the optimum process parameters. The trained sensory panel can finally evaluate and characterise the end product. This evaluation can be linked to the preference of consumers. In the situation that one product is preferred over another, the sensory evaluation by the trained panel can give an indication for demands of consumers or can be used as a tool to set out standards for improvement of the food product.

The evaluation and measurement of commercial chocolate has the main drawback that the complete ingredient list is not known in detail and that no information is available on the production process, transportation, storage or even the type of cocoa bean that was used. The only available information was found on the package. Further the samples were treated anonymously. Therefore it can be difficult to explain significant differences among chocolates. However, using commercial samples has the advantage that these are products that are actually consumed by consumers and are therefore known to have a minimum of preferred attributes.

Further research should be performed to find correlations between the sensory evaluation of aroma and flavour attributes and instrumental measurements of these attributes.

Chapter 3

Knowledge gain by combination of instrumental analysis and sensory analysis: three case-studies on chocolate

Adapted from:

De Pelsmaecker, S., Gellynck, X., Delbaere, C., De Clercq, N., Januszewska, R., Hegyi, A., Kuti, T., Depypere, F., Dewettinck, K. (2013). The influence of different storage conditions and fat bloom on sensory characteristics of pralines. *Food Science and Law*, 4 (2), 45-51

De Pelsmaecker, S., Juvinal, J.G., Lagast, S., Schouteten, J.J., Dewettinck, K., Gellynck, X. Influence of chocolate texture on Belgian consumers' emotions and affective ratings. *In Journal of Food Quality (Under review)*

De Pelsmaecker, S., Behra, J., Schouteten, J., Dewettinck, K., Gellynck, X. Difference in threshold detection of graininess in chocolate: machine vs human. Oral presentation at Food Structure and Functionality Forum (30/03/14-02/04/14, Amsterdam)

Abstract

This chapter is a compilation of three studies that focused on the correlation between data from sensory analysis and instrumental analysis. The first study identified the sensory changes of filled chocolate on which fat bloom has developed. This study showed how sensory analysis can contribute to instrumental measurements. The second study focuses on the graininess of chocolate and the possibility to influence preference. The results show how the combination of the sensory data and the instrumental data can lead to new insights for product but also process innovation. The third and final study researches how an overall sensory profile of a product and specifically texture attributes can influence consumers' preference.

All the results in this chapter from relation between instrumental analysis and sensory analysis on differentiation of products, the detection of graininess or the influence on acceptance, illustrate how complementary sensory and instrumental measurements can be if the proper tests are used to answer a specific research question.

3.1. Introduction

Sensory analysis is defined as a scientific method used to evoke, measure, analyse and interpret reactions to products as they are perceived through the senses of sight, smell, taste, touch, and hearing (Stone and Sidel, 2004c). The sensory evaluation of quality of food is an important parameter for marketers and product developers in food industry in terms of designing, testing, launching, and rethinking food products as it collects informative and empirical data that addresses how sensory systems function, from stimulation and perception to cognition and behaviour (MacFie, 2007). Many instruments are not as sensitive as the human sensory system which makes sensory analysis an attractive tool to gain more knowledge on a product or a product characteristic.

In the past 60 years, sensory analysis has developed remarkably and has gained an increasing number of users in the food industry (Sidel and Stone, 1993). Nowadays, the importance of sensory analysis in food industry is well recognized and frequently applied. Many food companies apply standard sensory tests or develop their own methods adapted to particular internal problems and purposes. This in return influenced the academic world which caused the development of new knowledge and methods.

However, most of the food companies limit the use of sensory tests to quality control and quality assurance instead of using it for new product development (Muñoz, 2002, ASTM, 1992b). They believe that the instrumental techniques adequately measure properties related to the products' quality, and that sensory tests are just a way to get some additional assurance that the taste is good. Moreover, methods are not always correctly used or the interpretation of the results is incorrect because there is not an expert in sensory analysis employed in the company (Sidel and Stone, 1993). This is specifically true for an SME as the resources might not be available to employ a sensory expert. On the other hand, there are companies that rely on instrumental measurement, but also insert a prior validation step through sensory assessments (Muñoz, 2002). These companies have done studies on the relationship between instrumental and sensory measurements for their products, hence sensory analysis is used as an indirect quality control (Weller and Stanton, 2002). Usually these are larger companies in which sensory analysis is a part of a 'Sensory and Consumer Insights' department.

Correlations between sensory and instrumental data have been the research topic in many studies on different food products such as tomatoes (Lee et al., 1999), bread (Gambaro et al., 2002), spaghetti (Martinez et al., 2007) and milk chocolate (Guinard and Mazzucchelli, 1999). Andrea-Nightingale et al. (2009) studied the textural changes of chocolate with both instrumental and sensory analysis. These authors used only a texture analyser as instrumental measurement and a trained panel. They concluded that the texture analyser was less discriminative than the trained sensory panel. As a limitation, these authors indicated that the instrumental analyses should be broader and that a consumer panel should

be consulted to get optimal results. Based on results of such correlation exercises, a food company could select some tools to analyse products instead of conducting all possible instrumental and sensory analyses. The validity of this approach is reliable, if a periodic revision of the initial identified relationships are done to incorporate new products, new product dimensions, and new encountered variability and problems (Muñoz, 2002). This chapter presents three studies which indicate the relationship between instrumental and sensory analysis and show how the results of both types of measurements can help to strengthen the knowledge on sensory acceptance of chocolate products.

When defining the quality of chocolate, the sensory properties of chocolate are considered to be the most important parameters (Popov-Raljić and Lalić-Petronijević, 2009). The liking of chocolate by consumers is mostly depending on the sensory acceptance (Mela, 2000, Parker et al., 2006). Texture is one the main drivers for consumer acceptance (Andrae-Nightingale et al., 2009). Due to the complex formulation, chocolate has a distinct mouth feel and texture (Sidel and Stone, 1983). This sensation is caused by the narrow melting point of cocoa butter, which is close to the body temperature (De Clercq, 2011). As such when chocolate is placed on the tongue it slowly melts due to the difference between room temperature and body temperature. Another key parameter for the acceptance of chocolate texture is the particle size (Morgan, 1994). Other sensory components such as flavour, aroma and appearance are also important for the quality of chocolate (Mela, 2000) and therefore these sensory characteristics will also be taken into account in the following studies to cover all sensory aspects.

The focus of this chapter is on the correlation between the sensory description by a trained panel and a consumer panel and instrumental analysis of the products. This chapter includes three different studies. The first study focuses on filled chocolates on which fat bloom has developed and the effect of fat bloom on sensory characteristics of appearance, aroma, flavour and texture. This part was published in Food Science and Law (De Pelsmaecker et al., 2013b). The second study researches the influence of particle size and therefore the graininess of chocolate on consumer preference. This part was orally presented at the Food Structure and Functionality Forum in 2014 (De Pelsmaecker et al., 2014). The third study focuses on the influence of sensory characteristics and specifically texture on acceptance by consumers. This part is submitted to Food Quality and Preference.

3.2. Study 1: The influence of different storage conditions on fat bloom and sensory characteristics of filled chocolates

3.2.1. Introduction

Chocolate is a complex suspension of solid particles such as cocoa mass and sugar in a continuous fat matrix of cocoa butter (Jaeger et al., 2008). Milk chocolate also contains milk powder or other raw materials. Plain chocolate has a shelf life of 12 to 24 months (Tuorila, 1996) although it depends on different parameters such as storage temperature, humidity, accessibility of oxygen and ingredients (Mexis et al., 2010). Those parameters are even more important in the case of filled chocolates, which are chocolate confections filled with a lipid substance such as nut paste or an alcohol filling (Ali et al., 2001, Choi et al., 2005). During storage, oil migration occurs depending on the different chemical and physical properties. This oil migration causes unwanted texture changes such as hardening of the filling and softening of the covering chocolate. Additionally, a recrystallization of the oil occurs which may eventually lead to fat bloom on the surface of the filled chocolate (Lonchampt and Hartel, 2004). Fat bloom can be described as a gradual change in colour and loss of gloss resulting a greyish appearance of the surface of chocolate (Briones and Aguilera, 2004) (Figure 3. 1). Thus, this oil migration results in texture, colour but also in flavour changes (Ali et al., 2001, Andrae-Nightingale et al., 2009).



Figure 3. 1: Fat bloom on one of the filled chocolates

As chocolate bloom can be considered as the number one quality problem in the confectionary industry (Depypere et al., 2009b), it has been subject to numerous research studies (Afoakwa et al., 2009b, Afoakwa et al., 2009c, Lonchampt and Hartel, 2004, Altimiras et al., 2007, Choi et al., 2005, Galdámez et al., 2009, De Graef et al., 2005). Several authors studied the effect of storage temperature on the appearance of fat bloom. Ali et al. (2001) stated that fat migration can occur at a considerable rate at room temperature (17°C – 23°C) and increases as the temperature increases. Khan and Rousseau (2006) studied the effect of three storage temperatures (11°C, 20°C and 26°C) on the migration kinetics and equilibrium states of a model for filled confection consisting of a hazelnut oil-based filling and dark

chocolate. After storage for 8 weeks, only the models stored at 26°C suffered from severe bloom and texture degradation. Additionally, migration and diffusion increased 20 to 400 times with a temperature increase of respectively 11°C to 26°C. Choi et al. (2005) showed that storage temperature was the most important factor for oil migration in milk chocolate. Lonchampt and Hartel (2004) stated that there are three temperature ranges, $T < 18^{\circ}\text{C}$, $18^{\circ}\text{C} < T < 30^{\circ}\text{C}$ and $> 32^{\circ}\text{C} - 34^{\circ}\text{C}$, at which different bloom properties occur. Moreover, it is proven that next to a high storage temperature, fluctuating temperature also causes and even accelerates fat bloom. The changing temperature causes the melting and the re-crystallization of low melting point crystals. The process has an impact on the microstructure, visual appearance and textural properties (Afoakwa et al., 2009b, Nöbel et al., 2009).

Next to storage temperature, the ingredients used for the filling of the chocolates also influence the development of fat bloom. Several studies were conducted on the influence of different milk fat or powder percentages (Choi et al., 2005, Walter and Cornillon, 2001, Tietz and Hartel, 2000, Sonwai and Rousseau) and some other studies focus on the impact of different levels of hazelnut oil (Smith et al., 2007, Nopens et al., 2008). Choi et al. (2005) indicated that high levels of milk fat promote softening because the liquid fraction behaves as a straight dilution effect, similar to liquid nut oils. This study confirmed the theory as presented by Lonchampt and Hartel (2004). In their review on fat bloom present on chocolate and compound coatings, these authors indicated that the cocoa butter simply dilutes in the nut oils.

Several studies have indicated that fat bloom causes changes in the sensory characteristics of chocolate or filled chocolates. A recent study indicated that fat bloom causes chocolate to be harder, less cohesive, less chewy and to have a longer melting time. Next to that, the chocolate has a less intense sweet taste and lower cream flavour (Andrae-Nightingale et al., 2009, Tuorila, 1996). When focusing on filled chocolates, Depypere et al. (2009a) stated that quality defects may arise by oil migration. Several defects that may occur are softening of the chocolate covering layer, hardening of the filling and deterioration in the sensorial aspect of the chocolate (appearance, colour taste). These authors indicated that after 10 months of storage, filled chocolates stored at 18°C could be discriminated from fresh filled chocolates. When the filled chocolates were partly stored at refrigerated temperatures, the filled chocolates could not be discriminated in taste from fresh chocolates.

Thus, previous studies have focused on the microstructural influences and causes of fat bloom but little on the sensory quality of filled chocolate and the changes during storage. Therefore, this study aims to identify influence of storage temperature and fat bloom on the sensory quality of filled chocolates. Colour measurements were conducted on the different variants to identify fat bloom. Further, a trained sensory panel evaluated the filled chocolate immediately after production and after three months of storage using quantitative descriptive analysis.

3.2.2. Materials and methods

3.2.2.1. Materials

Six different formulations of filled chocolates, composed of milk or dark chocolate and hazelnut or alcoholic fillings, were prepared differing in covering chocolate and/or filling as shown in Table 3. 1. The products were produced at the UGent Cacaolab. A standard tempering procedure was used for dark and milk chocolate. The chocolate was filled in the mould to form the chocolate shell. The hazelnut fillings were tempered on a marble plate whereas the alcoholic fillings were heated to 28°C. Both fillings were sprayed in the chocolate shells with a piping bag. The filled chocolates were closed by a chocolate layer and were subsequently coded. Finally, they were cooled for 30 minutes on 20°C, followed by storage at 15°C for \pm 12 hours.

Table 3. 1: Overview of the six produced variants

Variant	Covering chocolate (% total fat content)	Filling
V1	Dark chocolate (32%)	Low level hazelnut oil (17% hazelnut paste)
V2	Dark chocolate (32%)	High level hazelnut oil (22% hazelnut paste)
V3	Milk chocolate (33%)	Low level hazelnut oil (17% hazelnut paste)
V4	Milk chocolate (33%)	High level hazelnut oil (22% hazelnut paste)
V5	Dark chocolate (32%)	Low level strawberry alcoholic (8.9% alcohol)
V6	Dark chocolate (32%)	High level strawberry alcohol (12.9% alcohol)

3.2.2.2. Storage

The filled chocolates were divided in three batches, of which one was immediately evaluated and the two other batches were stored at a different temperature. The fresh filled chocolates were used as reference for comparison of the filled chocolates stored at 20°C and 23°C. The second batch was stored at 20°C which is a control temperature at which oil migration is slow but significant. The third batch is exposed to a fluctuating room temperature with a mean of 23°C in an office at the Ghent University with an upper and lower range of 1,5°C. This is the closest to how consumers keep their filled chocolates stored in their homes. The intention of the study was to mimic as close as possible the consumer's environment.

3.2.2.3. Sensory analysis

A trained panel was used to create the sensory profile of the produced filled chocolates. The use of sensory analysis techniques with trained assessors provides an objective measurement of the sensory characteristics of the filled chocolates; thus descriptive methods are adopted which show differences between samples.

Trained panel

The trained panel is set up as described in section 1.6.1.2. During the first training sessions, the panellists established a list of 28 attributes through evaluation of related samples (Table 3. 2). Lawless and Heymann (1999) state that sensory scientists should be careful about restricting the type and number of attributes. This could mean a loss in information that was gathered. The required definitions for these appearance, aroma, texture and flavour attributes were generated. After these sessions, the panel leaders compiled a standard procedure in which the panellists needed to evaluate the filled chocolates. Continuous panel performance and monitoring techniques were used to ensure all assessors maintained a high level of competence (Moussaoui and Varela, 2010).

Table 3. 2: Overview of the 28 descriptors for evaluation of filled chocolates

Appearance	Aroma	Texture	Flavour
Gloss	Chocolate aroma	Snap	Chocolate
Intensity of colour	Sweet	Hardness	Specific
Blooming	Bitter	Melting in mouth	Alcohol
Cracking	Sour	Greasiness	Sweet
Air bubbles	Burned	Smoothness	Bitter
Leakage of the filling	Specific aroma (filling)	Heterogeneity	Sour
	Alcohol aroma (filling)	Density	Spicy
			Aftertaste

Quantitative Descriptive Analysis

The development of the evaluation procedure was based on the principles of quantitative descriptive analysis (QDA). The panellists were retrained on this QDA procedure over a period of 10-15 hours (Murray et al., 2001) (section 1.6.1.2).

Each panellist received a three digit blind coded sample in two replicates. A Latin-square design (software generated) was used in order to minimize the carry over and order effects (Wakeling and MacFie, 1995). A similar procedure was used as in section 2.2.4.1.

3.2.2.4. Instrumental analysis

Colour measurement

Colour measurements were conducted as described in section 1.6.1.2. The Whiteness Index (WI) is used as indicator of white colour development due to fat bloom formation and made it possible to compare different samples (Altimiras et al., 2007). The WI is based on the Euclidian distance between a particular CIE-Lab coordinate and the white point at $L^*/a^*/b^*=100/0/0$ (Anonymous, 2007, Bricknell and Hartel, 1998). WI data are normally calculated with the following equation:

$$WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2}$$

For every variant, 8 filled chocolates were randomly selected for measurements. The colour of the bottom of the chocolates was measured at three different locations for each sample.

Texture analysis

A three point bent test was performed (section 1.6.1.2) to measure the fragility which is the maximum load [N] necessary to fracture the filled chocolate. The depression limit for the measurement was 5 mm and the probe descended at 10 mm/min, until the filled chocolates cracked. For every variant of the filled chocolates, ten samples were randomly subjected to the three point bend test.

3.2.2.5. *Data analysis*

First, analysis of variance is carried out to test if there are significant differences between the means of samples (products) for the measured parameters of instrumental analysis (Cartier et al., 2006). Moreover, a two-way ANOVA was done to identify the significant differences between the sensory attributes. The Neuman Keuls multiple comparison test is therefore applied to determine whether the samples are significantly different for each attribute at a specified level of significance (5%).

3.2.3. Results

3.2.3.1. *Colour measurement*

The colour was measured after 3 months of storage at 20°C and 23°C using the L*, a*, b*, coordinates. Based on these measurements, the whiteness index was calculated for all the different variants (Table 3. 3). The effect of storage is explained by comparing the three temperatures for the six variants.

For V₁, a slight increase of the WI is measured however this was not significant. The results for V₂ indicate that the WI increases after storage and as function of temperature. For V₃, no significant differences were measured. For V₄, significant differences were found. V₅ chocolates show an increase of WI with higher temperature. For V₆, the WI for samples stored at 20°C is significantly different from the fresh filled chocolates. Although the WI for the samples stored at 23°C is also higher, it is not significant.

Table 3. 3: Mean values and standard deviation of the whiteness index for all six variants (n=3)

	V ₁	V ₂	V ₃	V ₄	V ₅	V ₆
Fresh	27.8 ± 0.4 ^a	27.3 ± 0.1 ^a	33.3 ± 0.3 ^a	33.1 ± 0.3 ^{a,b}	26.0 ± 1.1 ^a	27.1 ± 0.3 ^a
20 °C	31.5 ± 3.8 ^a	31.3 ± 1.7 ^b	33.7 ± 0.5 ^a	33.7 ± 0.6 ^b	34.8 ± 3.8 ^b	31.3 ± 1.6 ^b
23 °C	31.61 ± 4.2 ^a	35.7 ± 2.3 ^b	33.9 ± 2.0 ^a	32.5 ± 1.3 ^a	40.5 ± 4.2 ^c	28.3 ± 0.8 ^a

^{a,b,c} presents means within the same column with different letter are significantly different.

3.2.3.2. Texture measurement

The measurements show that for V1 and V2 the maximum load to break the filled chocolates was significantly higher after storage at 20°C (Table 3. 4). For V2, this increase is measured for storage at 23°C as well although it is lower than stored at 20°C. Likewise, the force to break V1 stored at 23°C is significantly lower than the necessary force after storage at 20°C. The analyses for V3 and V4 give similar results. Although the initial values of V3 and V4 are significantly different due to the amount of hazelnut oil in the filling, they both soften after storage at both temperatures.

The two alcohol filled chocolate show a different behaviour. While storage at 20°C increases the hardness of V5 and decreases at storage at 23°C, the hardness of V6 increases after storage at both temperatures. Confirmation and explanation of these different behaviours will be further analysed in the sensory evaluation by the trained panel. Moreover, it is suspected that fat bloom occurs from different mechanisms in these two different fillings.

Table 3. 4: Mean values and standard deviation for hardness measurement for six variants (n=10)

	V1	V2	V3	V4	V5	V6
Fresh	57.2 ± 7.7 ^a	62.2 ± 13.6 ^a	81.5 ± 19.5 ^c	49.9 ± 14.6 ^b	89.6 ± 21.6 ^b	26.1 ± 6.7 ^a
20°C	112.9 ± 10.1 ^b	76.4 ± 7.2 ^b	50.7 ± 4.7 ^a	35.6 ± 2.6 ^a	99.7 ± 10.1 ^b	44.9 ± 19.1 ^b
23°C	53.1 ± 9.5 ^a	73.3 ± 9.4 ^b	67.1 ± 8.6 ^b	39.6 ± 4.8 ^a	67.0 ± 6.4 ^a	72.3 ± 9.4 ^c

^{a,b,c} presents means within the same column with different letter are significantly different.

3.2.3.3. Sensory analysis

Fresh filled chocolates: influence of ingredient

In order to identify the sensory differences caused by the ingredients, the fresh filled chocolates were compared within the same group thus V1 with V2, V3 with V4 and V5 with V6. Immediately after production, V1 and V2 are only significantly different for hardness ($p < 0.001$) and melting in mouth ($p = 0.045$). V1 is harder and melts slower than V2, which is due to the lower percentage of hazelnut oil in the filling. The trained panel did not detect any significant differences between V3 and V4 after production. The chocolates filled with an alcohol filling (V5 and V6) had a different gloss ($p = 0.019$) and a different amount of air bubbles ($p = 0.003$). As the gloss was higher and the air bubbles lower for V6, it might be suggested that this is due to production of V5. Next to that V5 was perceived as harder ($p = 0.018$) and slower melting ($p = 0.004$) than V6 which can be related to the higher alcohol level in V6 which is in line with the texture measurements.

Comparison of fresh and stored filled chocolates: influence of storage

Based on the visible bloom recorded by the researchers and the colour measurements, only three variants were chosen to perform sensory analysis on for storage at 20°C as well 23°C namely V1, V4 and V5. This was a precaution as not to overload the trained panel.

Figure 3. 2 shows the results for the attributes that are significantly different for V1. The sensory analysis shows little difference in gloss. However, the panel indicated that the

intensity of the colour is significantly lower after storage at 23°C which is linked to the higher amount of fat bloom. The filled chocolates stored at 20°C and 23°C have a less distinct aroma profile such as lower chocolate, bitter and specific (=hazelnut) aroma. These results suggest that aromas tend to fade due to storage or fat bloom. The texture attributes hardness and homogeneity decrease significantly after storage. Finally, the fresh filled chocolate has a moderate bitter flavour which decreases slightly for storage at 20°C and significantly for storage at 23°C.

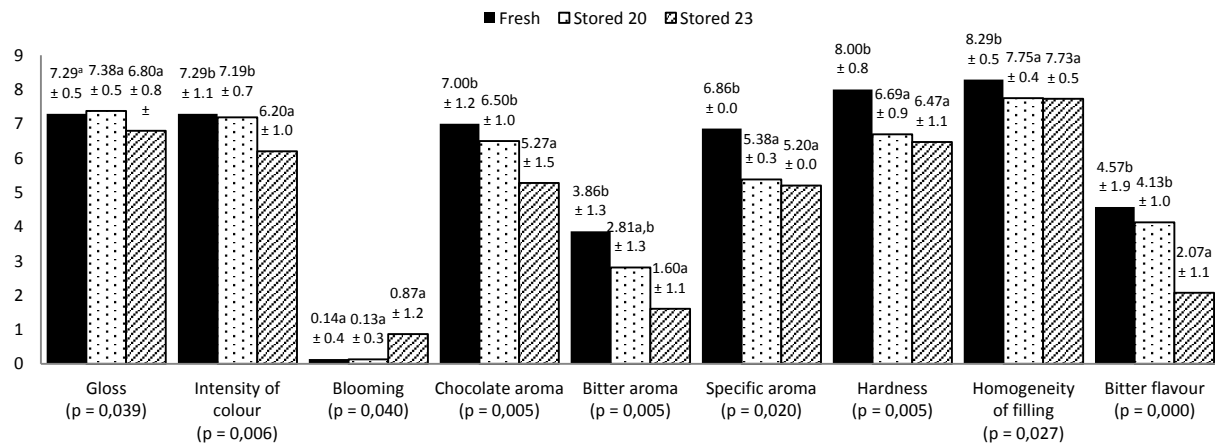


Figure 3. 2: Significant differences for sensory attributes between the V1 samples for fresh, stored at 20°C and 23°C

a,b,c presents significant differences between mean values for every storage condition of V1

For V₄, the gloss of the filled chocolate is rated as significantly higher due to storage (Figure 3. 3). This can be explained as fat bloom on milk chocolates is more difficult to detect visually than when it appears on dark chocolate. The texture attributes snap and hardness decrease during storage. Further, the sweet flavour fades to a lower intensity during storage. These results indicate that fat bloom also affects the sensory characteristics, particularly texture and sweet flavour, of filled chocolates with a milk chocolate cover.

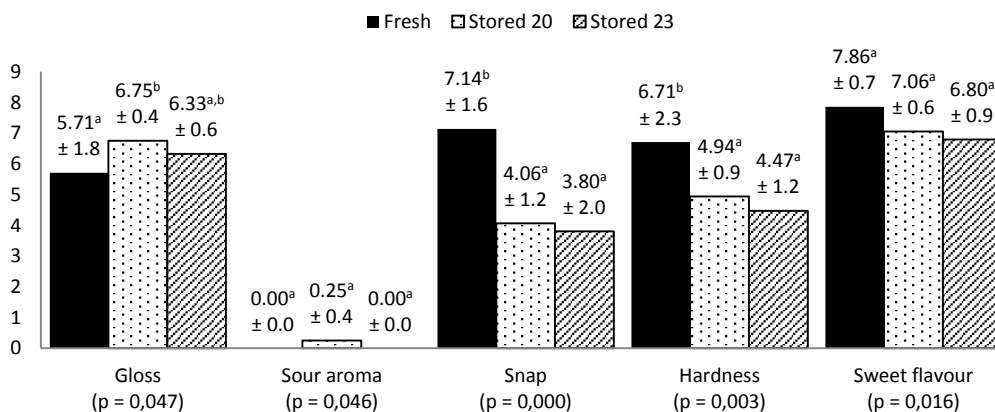


Figure 3. 3: Significant differences for sensory attributes between the V4 samples fresh, stored at 20°C and 23°C

a,b,c presents significant differences between mean values for every storage condition of V4

The trained panel identified few changes on the dark chocolates with alcohol filling due to storage and fat bloom (Figure 3. 4). The gloss of stored filled chocolates is evaluated as significantly higher than on fresh samples. This indicates that the process of fat bloom formation is difficult to assess. Further, the density of the filling increases suggesting that an unknown process is altering the texture of the alcohol filling. Finally, the specific alcohol flavour decreases during storage. Although the detected differences caused by storage are rather small, fat bloom is anyhow altering the characteristics of these types of filled chocolates as well.

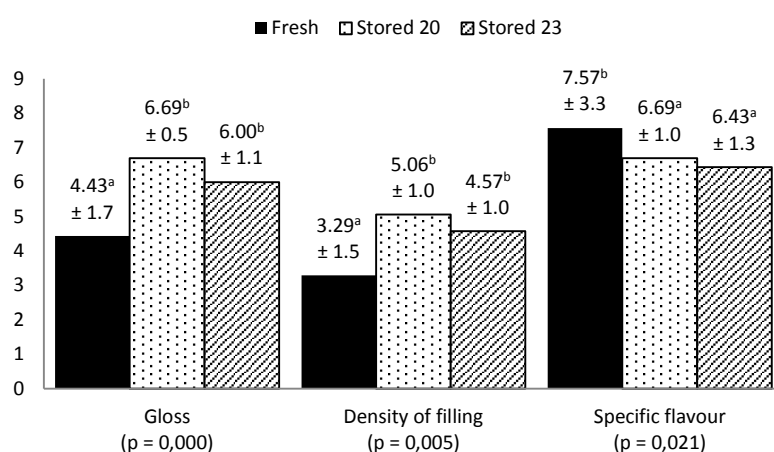


Figure 3. 4: Significant differences for sensory attributes between the V₅ samples fresh, stored at 20°C and 23°C
a,b,c presents significant differences between mean values for every storage condition of V₅

3.2.4. Discussion

Ali (2001) studied the effect of storage on the sensory characteristics of chocolates but limited this study to the general terms 'colour', 'texture', 'flavour' and 'overall acceptability'. The current study deepens the knowledge on sensory changes after storage of different sensory attributes and thus gives a more complete overview of the influence of storage and ingredients. Moreover, these results help to intercept the possible defects that a chocolate producer needs to understand before changing a recipe, altering storage conditions or even when implementing actions to reduce fat bloom.

This study confirms previous studies which indicated that fat bloom alters the sensory characteristics of chocolate and filled chocolate (Ali et al., 2001, Andrae-Nightingale et al., 2009, Tuorila, 1996). Colour measurements showed significant changes to the surface colour especially for the filled chocolates with dark chocolate cover. For one variant with milk chocolate (V₃), no difference was found. It is possible that fat bloom did occur although it was not visible due to the lighter colour of the milk chocolate. This was confirmed by the evaluation of the trained panel. Interestingly, the trained panel was able to detect a significant difference in the gloss of V₁, while this was not found with the colour measurement. To detect fat bloom, it is therefore advisable to work with the trained panel to evaluate this characteristic for filled chocolates. The spectrophotometer measures the colour

at a specific spot. Even though, different points are measured for one piece of filled chocolate, a trained panel has the advantage to see the complete product and therefore evaluates the complete product.

Previous literature indicated that fat bloom changes the texture of chocolate and filled chocolates (Depypere et al., 2009a). This study confirms these results as both instrumental and sensory analysis show significant differences for the hardness of the hazelnut filled chocolates. The literature states that oil from the filling migrates to the covering chocolate which softens the cover but hardens the filling. However, for V1 the instrumental analysis indicates that the cover becomes harder after storage at 20°C and remains equally hard at 23°C. It must be taken into account that this type of analysis only evaluates the covering chocolate and therefore only captures the hardness of the couverture layer. The trained panel indicates a decrease in hardness for both storage temperatures. Again, the trained panel bites through the complete filled chocolate and can therefore evaluate both the cover and the filling of the filled chocolate. The texture analysis only cuts through the cover chocolate at one specific point. Moreover, it only cuts through the cover and not the filling. Similar as with the colour measurement, the data of the trained panel provide a better understanding of the change in texture of the filled chocolate.

Very little is known on alcohol fillings, this study presents some interesting results on instrumental and sensory analysis. Although the density of both low and high alcohol filled chocolates increases, the texture measurements indicates that the two variants have significantly different characteristics under fresh, stored at 20°C and stored at 23°C conditions. Further research is necessary to reveal which processes are altering these characteristics during storage. Although this study goes more into detail on the altering of different sensory characteristics than previous studies, these results confirm previous stated effects of fat bloom (Ali et al., 2001).

Moreover, the results indicating that the aroma and flavour is altering during storage are interesting. For V1 and V2, the aromas that define these samples (chocolate, bitter and specific hazelnut) are changing from high intensity to moderate. All samples have one flavour, bitter for V1-V2 and specific sweet flavour for V3-V4 and specific flavour (alcohol) for V5 – V6 that significantly decreases during storage. It would be interesting if these changes can be picked up in further studies with instrumental analysis through GC-MS aroma component detection and find the correlations between sensory and instrumental analysis.

3.2.5. Conclusion

This study indicates the importance of a trained panel. First, the trained panel does not measure or evaluate a specific part of the filled chocolates but the overall product. Accordingly, the vision of a trained panellist can more accurately recognize changes in the appearance of the chocolate which was not captured by the colour measurement. By taking a bite of the filled chocolate, panellists are also able to distinguish different products from

each other. Therefore, when conducting storage tests and shelf life tests, it is advisable to use a trained panel to evaluate the chocolates instead as it can provide complementary information to the results of instrumental measurements.

Second, this study shows that the threshold to detect a difference for a sensory attribute can be different for a machine and a human. In this case the human sense was more successful and therefore the trained panel should be used to objectively evaluate products which are ready for the market. The detection point of the trained panel will be closer to the detection point of the consumer than a machine. If a consumer detects a sensory difference, this will also be recognized by a trained panel whereas a machine might not be able to pick up this difference.

3.3. Study 2: Difference in threshold detection of graininess in chocolate: machine vs. human

3.3.1. Introduction

Chocolate is defined as a suspension of sugar particles and cocoa solids in a continuous fat phase (cocoa butter) (Jaeger et al., 2008). This fat phase is solid below 25°C. It melts in the mouth and becomes completely liquid, the sugar and cocoa particles remaining in suspension. It is assumed in literature that there is a critical size value below which those particles are not perceived by human beings. This value is between 25 and 35 µm depending on the publications (Engelen et al., 2005, Afoakwa et al., 2007). Above this value, the chocolate is perceived as gritty. However, it has been impossible to find the origin of this value.

Moreover, previous studies have indicated graininess as an important characteristic for the consumers' acceptance of chocolate (Morgan, 1994). Therefore, the main aim of this work is to determine if the set-up standard critical point that the industry has defined is justified. Moreover, it explores what the threshold is at which humans, both trained panel and consumers, can detect particles in chocolate. In other words, identifying the maximum unperceived size of those particles. Therefore, chocolates with different particle size distribution (PSD) are produced and analysed with instrumental analyses and sensory analyses.

3.3.2. Materials and methods

3.3.2.1. Samples

Ingredients

The chocolate for this study was composed of 48% pre-refined sugar, 40% cocoa mass, 11.60% cocoa butter and 0.40% soy lecithin. The fat content of the final chocolate is 33.6%.

Chocolate production

As specific PSD is obtained through alterations in the production process, all the production steps are described in detail.

The cocoa mass and the cocoa butter were put overnight at 50°C in order to melt them completely. The ingredients were weighted and added in the following order: cocoa mass, 27 mass% of the total cocoa butter and sugar. Those three ingredients were mixed together for 20 min at 45°C (Vema BM 30/20 mixer, Machinery Verhoest, Belgium). Refining was performed with an Exakt 8oS 3-roll refiner (E and R Chemicals and Equipment B.V., The Netherlands). The rotation speed of the rolls was set at 400 rpm. Temperature of the rolls, distances between rolls and number of refining steps varied for each sample in order to obtain

different particle size distributions. These parameters were chosen according to a previous study (Rueda Sagredo, 2011) (Table 3. 5).

Table 3. 5: Parameters used for the refining during chocolate production

Expected D₉₀ (µm)	30	40	50
Roll temperature (°C)	35	45	45
Distance between the first and the second rolls	3	3	4
Distance between the second and the third rolls	1	1.5	2
Number of refining steps	2	1	1

After this refining step, particle sizes were controlled with a handheld micrometer (Ref. 293-821, Mitutoyo, Belgium) immediately after refining. Therefore, around 0.40 g of each sample was dissolved in the same mass of paraffin oil before measurements. Three measurements were performed for each sample. Three samples of 0.50 g refined chocolate were taken in small plastic flasks for each chocolate in order to determine the PSD. Refined chocolates were stored at room temperature before conching.

The refined product was weighted and put in the conching machine with addition of some more cocoa butter (Bühler ELK'olino conche, Bühler Group, Germany). The quantity of added cocoa butter represented 1% of the refined product mass put in the conche. The program used for dry conching is presented in Table 3. 6. The remaining cocoa butter and the lecithin were added to the refined product. The program used for wet conching is presented in Table 3. 6. Again, 3 samples of 0.50 g conched chocolate were taken in small plastic flasks for each chocolate in order to determine the PSD. Chocolates were stored at room temperature before tempering.

Tempering was performed manually. Conched chocolates were put overnight at 45°C before tempering in order to melt them completely. It was divided into 2 parts of the same mass. One part was kept aside and heated. The second one was spread on a marble table. This chocolate was then collected together in the middle of the table. It was kept in motion by a succession of chocolate spreading and collecting. The temperature was controlled regularly. When chocolate temperature reached 32-33°C, it was collected and put together with the first part.

All the chocolate was thoroughly mixed with a plastic spoon. A sample was taken and analysed with a temper meter (Chocometer™, Aasted Mikroverk, Denmark). Three parameters were obtained to control the quality of tempering. As an indication that the chocolate was well tempered, the slope of the tempering curve needs to be as close as possible to 0. The Chocolate Temper Unit (CTU), which is an aggregated value, must be higher than 22°C, and the Tempering Index (TI), another aggregated value, must be between 4 and 6. When the temperature of the total chocolate mass reached 32-33°C, chocolate was formed. Three samples of 0.50 g tempered chocolate were taken in small plastic flasks for each chocolate in order to determine the PSD.

Table 3. 6: Dry conching program used during the production of the chocolates

Dry conching				
Step number	Duration (min)	Temperature (°C)	Rotary speed jump	Rotation speed (rpm)
1	1	25	-	-
2	120	60	Clockwise	1200
3	240	70	Anti-clockwise	1200
Wet conching				
Step number	Duration (min)	Temperature (°C)	Rotary speed jump	Rotation speed (rpm)
1	15	45	Anti-clockwise	2400
2	15	45	Clockwise	2400

Bar moulds were heated with a heating gun prior to the filling. Air bubbles were removed on a vibrating table, and the moulds were put in cooling cabinets (Cooled working table M1298, Chocolate World's, Belgium) at 9-12°C and 42% Residual Humidity. Chocolate droplets for sensory analyses were formed directly with a pastry bag on aluminium plates covered by greaseproof paper. Then, the same procedure as for the bars was used.

After cooling, bars were removed from the moulds and stored in small cardboard boxes at 20°C. Chocolate droplets were stored in the same conditions in bigger boxes. For both shapes, chocolate levels were separated by greaseproof paper.

3.3.2.2. Instrumental analyses

Determination of PSD

PSDs were determined with as described in section 1.6.1.2. A similar procedure as in section 2.2.3.5 was used. PSD curves, $D_{4,3}$, $D_{V,10}$, $D_{V,50}$ and $D_{V,90}$ were determined for all the 3 chocolates at each manufacture step (refining, conching, tempering) and for the cocoa mass and the sugar.

Differential Scanning Calorimeter (DSC) measurements

Chocolate melting behaviour was determined (section 1.6.1.2). Small chocolate pieces of 5 to 10 mg were cut from chocolate bars and placed in small aluminium cups, which were closed hermetically... Three samples from each chocolate were prepared using a different chocolate bar for each sample. The temperature program of the DSC was identical to the one described in section 2.2.3.4.

Determination of the hardness

The maximum load was determined using penetration tests performed with a 8942 Texture Analyser (Instron, USA). Therefore, chocolate bars were used. The needle rate was set at 2 mm/s. The detection started when the force reached 0.2 N, and stopped when the needle was 5 mm deep in the bar. The maximum required force indicates the hardness of the sample. Those measurements were performed on 10 different bars for each chocolate at 20°C.

3.3.2.3. *Sensory analyses*

Trained panel

The trained chocolate panel (section 1.6.1.2) was used for the sensory evaluation of the chocolates in this study. As a check-up of the panel performance, a standard descriptive test was carried out to check what differences could be observed between three commercial available chocolates. The results of this test indicated that limited retraining was necessary specifically on graininess, as this study focuses on texture. After the retraining of approximately 10 hours, a discrimination test and a descriptive test were performed. All the evaluations took place at the UGent SensoLab and 8 panellists participated in the tests. During all the tests, panellists were sitting in individual testing booths under red light. They were provided with water and crackers and asked to rinse their mouth before starting the evaluation and as often as it was indicated in the evaluation procedure. Each chocolate was coded with a 3-digit number code on a plastic plate. The presentation order on the plates was randomized among panellists.

Discrimination tests

Panellists were submitted to 2 different types of discrimination tests: a triangle test and a ranking test. Both of those tests focused on graininess.

Triangle test

The aim of this test (section 1.6.1.2) was to explore whether there is a significant difference in graininess between the two lowest grainy chocolates as these are within the range set – up by the chocolate industry. Each panellist had to evaluate 3 series of 3 chocolates. The possible sequences of the series was also counterbalanced among panellists. The respondents were told that there were 2 samples with the same graininess and 1 sample with another graininess. They were asked to determine this odd sample.

Ranking test

The aim of this test (section 1.6.1.2) was to check whether there is a significant difference in graininess between the 3 different chocolates. Panellists were asked to rank the chocolates from the lowest graininess to the highest one. This test was performed twice.

Descriptive test

The aim was to determine graininess reference values for the two highest grainy chocolates and to determine other sensory differences between those two chocolates. For each chocolate, panellists were asked to evaluate snap, hardness, sweetness, bitter flavour, graininess, film formation in the mouth and residuals in the mouth. For every attribute, the assessors scored the product on a 0-9 category scale, anchored with the 'none' and 'high'.

Consumer panel

This consumer test was performed in 2 parts, one at a central location in France and the other at the UGent SensoLab. This was an explorative consumer test to find out if the results are in

line with the trained panel. The first part was conducted in Ardèche (France). The tests took place in a large room in which consumers were sitting separate on different tables. Each chocolate was coded with a 3-digit number code. Chocolate droplets (Figure 3. 5) were presented on 3-shared plates prepared just before the evaluation. The presentation order on the plates was randomized among consumers. The second part of this consumer test was conducted in the UGent SensoLab. The test procedure was similar in the first and second test. The aim of this study was to find if a normal chocolate consumer could perceive higher PSD. Two contexts were used to perform this test to see if this differentiation was identical for people who are more (in the lab) or less (in France) focused on the task.



Figure 3. 5: Chocolate droplets as presented in the consumer test

It took the consumers approximately 15 minutes to complete the questionnaire. First, they had to indicate their preference for the three chocolates on a 9-point balanced hedonic scale. Second, the respondents needed to evaluate graininess and residuals on a 5-point just-about-right scale. The third part was a ranking test. Consumers were asked to rank the three samples from the lowest to the highest graininess. Finally, some additional socio-demographic questions were asked at the end of the questionnaire.

3.3.2.4. *Data analysis*

Most of the statistical calculations were carried out with SPSS Statistics (Version 20.0.0, IBM®). Statistical analyses were performed for both instrumental and sensory analyses to see whether there are significant differences between the 3 chocolates. Therefore, different models of variance analysis were used depending on the cases. For instrumental analyses, a One-Way ANOVA was used. For the descriptive test with the trained panel, a Wilcoxon Signed Rank test was used. For the acceptance and the attribute tests with the consumer panel, an ANOVA with repeated measures was used. Frequency calculations about socio-demographics data were also performed with SPSS.

Results of the ranking tests were processed manually with the Least-Significant-Difference (LSD) test (Lawless and Heymann, 1999). For each chocolate, the ranks indicated by all the respondents were summed. The LSD was calculated with equation 1, in which N and K are respectively the number of panellists and the number of ranked chocolates. Chocolates whose rank sums differed by more than the LSD were considered significantly different.

$$LSD = 1.96 \sqrt{\frac{NK(K+1)}{6}} \quad (1)$$

Results of the triangle test were processed manually with the binomial law. The sum of each panellist score was calculated. It was compared to the minimum value that should be obtained to have a significant difference between the samples at 5% according to the binomial law. This sum must be higher than the reference value to consider the chocolates significantly different from each other.

3.3.3. Results

3.3.3.1. Instrumental analyses

Determination of PSD

PSD of cocoa mass and sugar

The PSD of the two grainy ingredients was determined prior to the production. Experimental results are reported in Table 3. 7. PSD curves are presented on Figure 3. 6. Those results confirm that cocoa mass particles are smaller than sugar particles.

Table 3. 7: Mean values and standard deviation of particle size distribution for cocoa mass and sugar particles (n=5)

	$D_{4,3}$ (μm)	$D_{v,10}$ (μm)	$D_{v,50}$ (μm)	$D_{v,90}$ (μm)
	Mean	Mean	Mean	Mean
Cocoa mass	17.9±0.5	2.0±0.1	11.5±0.2	43.8±1.5
Sugar	75.0±21.0	7.4±1.7	53.0±15.0	176.6±49.0

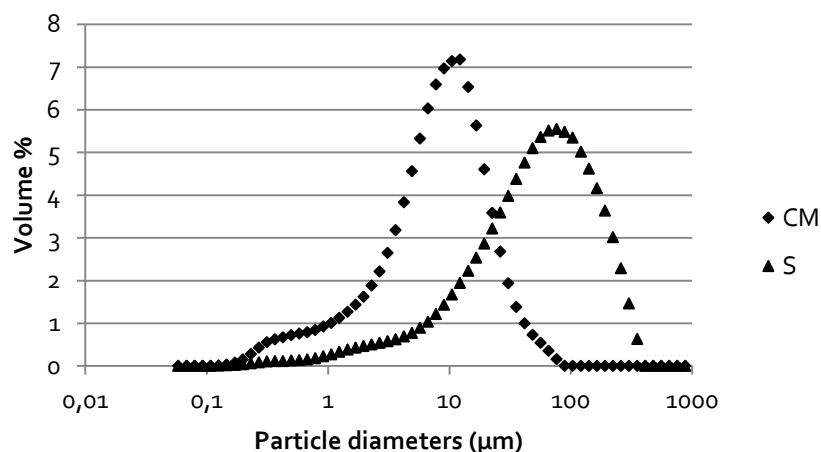


Figure 3. 6: PSD curves of cocoa mass (CM) and sugar (S) particles

PSD parameters of the 3 studied chocolates

As can be seen in Table 3. 8, the effective $D_{v,90}$ obtained for the two chocolates with the lowest expected PSD is close to this expected $D_{v,90}$, which were respectively 30 μm and 40 μm. They

will next be called respectively "30 μm chocolate" and "40 μm chocolate". However, the $D_{v,90}$ obtained for the last chocolate is around 60 μm whereas the expected value was 50 μm . This chocolate will then be called "60 μm chocolate".

A significant difference was found between the three tempered chocolates for all the calculated parameters except for $D_{v,10}$. This result can be explained by the origin of the smallest particles. Indeed, these particles come from the cocoa mass and are so small that their size is not reduced during chocolate production. Since the same cocoa mass has been used for all 3 chocolates, the smallest particles have the same size.

Table 3. 8: Mean values and standard deviation of particle size distribution for the 3 studied chocolates (n=5)

	$D_{4,3}$ (μm)	$D_{v,10}$ (μm)	$D_{v,50}$ (μm)	$D_{v,90}$ (μm)
	Mean	Mean	Mean	Mean
30 RC	13.8 \pm 0.1	1.6 \pm 0.1	8.9 \pm 0.1	34.1 \pm 0.1
30 CC	13.1 \pm 0.3	1.4 \pm 0.0	8.1 \pm 0.2	32.9 \pm 0.8
30 TC	13.4 \pm 0.5	1.6 \pm 0.3	8.5 \pm 0.6	32.9 \pm 1.1
40 RC	18.2 \pm 0.3	2.3 \pm 0.3	12.1 \pm 0.2	43.5 \pm 1.3
40 CC	15.7 \pm 0.7	1.6 \pm 0.1	9.8 \pm 0.4	39.0 \pm 1.6
40 TC	16.1 \pm 0.2	1.9 \pm 0.3	10.4 \pm 0.5	39.2 \pm 0.9
50 RC	23.9 \pm 1.6	1.9 \pm 0.1	12.6 \pm 0.9	63.5 \pm 3.6
50 CC	22.7 \pm 1.4	1.8 \pm 0.1	11.9 \pm 0.9	60.5 \pm 3.1
50 TC	22.5 \pm 0.7	1.8 \pm 0.1	11.9 \pm 0.4	59.8 \pm 1.5

SD: Standard Deviation; 30, 40, 50: expected $D_{v,90}$; RC: Refined Chocolate; CC: Conched Chocolate; TC: Tempered Chocolate

PSD curves of the 3 final chocolates

Only the PSD curves of the 3 final chocolates (tempered chocolates) are presented, since it is on these chocolates that instrumental and sensory analyses have been performed (Figure 3. 7). The smallest particles can be attributed to the cocoa mass particles, whereas the largest particles correspond to sugar particles.

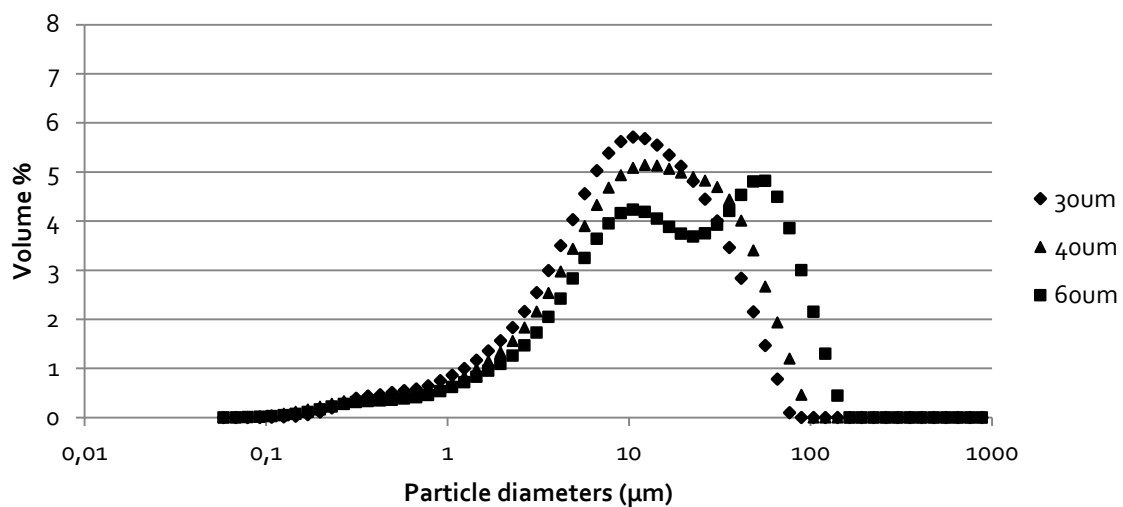


Figure 3. 7: PSD curves of the 30 μm TC, the 40 μm TC and the 60 μm TC (TC: tempered chocolate)

The 30 μm and the 40 μm chocolates have a $D_{v,90}$ close to the expected value. However, this is not the case for the last chocolate which has a $D_{v,90}$ of 60 μm instead of 50 μm . Other refining parameters should be tested in order to obtain the expected $D_{v,90}$. Since these three produced chocolates have significantly different sizes of particles and especially significantly different sizes of biggest particles, further instrumental and sensory analyses have been carried out with these samples.

DSC measurements

Statistical analyses of the DSC measurements indicated that there is no significant difference between the three chocolates for those parameters. It can be concluded that melting behaviour is not influenced by particle sizes in this range of particle sizes.

Determination of the hardness

The results of hardness measurements are presented in Table 3. 9. Statistical analysis showed that there is no significant difference of hardness between the 40 μm and the 60 μm chocolates ($p=0.920$). However, there is a significant difference of hardness between the 30 μm and the 40 μm chocolates ($p<0.001$) and between the 30 μm and the 60 μm chocolates ($p<0.001$). This result must however be taken carefully since hardness is influenced by tempering. Indeed, manual tempering can lead to different characteristics.

Table 3. 9: Mean values and standard deviation for hardness measurement of the 3 chocolates (n=10)

		30 μm	40 μm	60 μm
Maximum load (N)	Mean	18.4 \pm 0.4	17.2 \pm 0.9	17.1 \pm 0.3

3.3.3.2. Sensory analysis with trained panel

Discrimination tests

Triangle test between the 30 μm and the 40 μm chocolates

As shown on Figure 3. 8, none of the panellists was able to find the odd sample three times. Some of them were not even able to find the odd sample in either one of the three sets. Statistical analysis showed that there is no significant difference between these two chocolates. Therefore, it can be hypothesized that an average consumer will not be able to perceive a difference between the chocolates with these particle size distributions.

Ranking test

As shown in Figure 3. 9, all the panellists were able to rank correctly the 60 μm chocolate. However 50% of them inverted the 30 μm and the 40 μm chocolates. According to these results, it is possible to detect the difference between the two chocolates with the lowest PSD and the 60 μm chocolate. Moreover, this confirms the results from the triangle test.

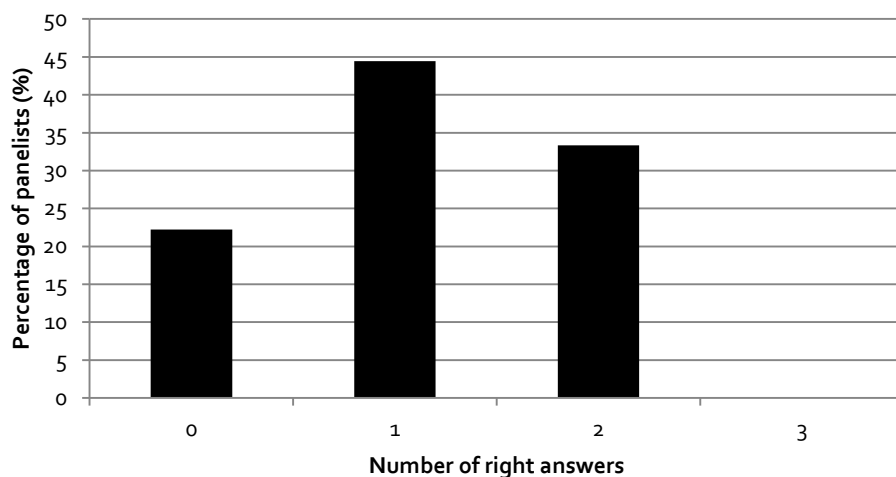


Figure 3. 8: Results of the triangle test (n=8)

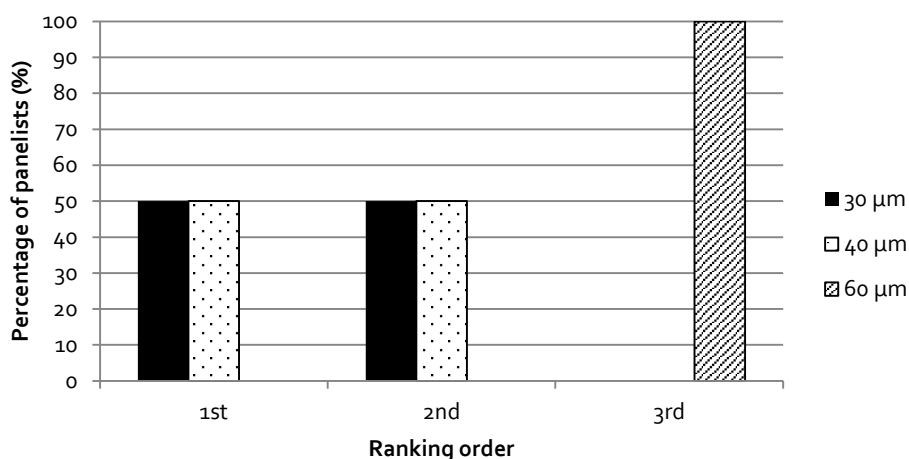


Figure 3. 9: Results for the ranking test on particle size (n=8)

Descriptive test for the 40 µm and the 60 µm chocolates

The QDA was performed on the 40 µm and 60 µm chocolate as the discrimination tests showed that no differences were found between the 30 µm and the 40 µm chocolates. This decreases the necessary evaluations for the trained panel.

No significant difference between those two chocolates was found for snap ($p=0.053$), sweetness ($p=0.739$), bitterness ($p=0.655$), film formation in the mouth ($p=0.705$) and residuals ($p=0.102$). A significant difference between the two chocolates was found for hardness ($p=0.031$) and graininess ($p=0.011$). All the panellists attributed a higher graininess score for the 60 µm chocolate than for the 40 µm one. The results obtained for these two chocolates are presented on Figure 3. 10.

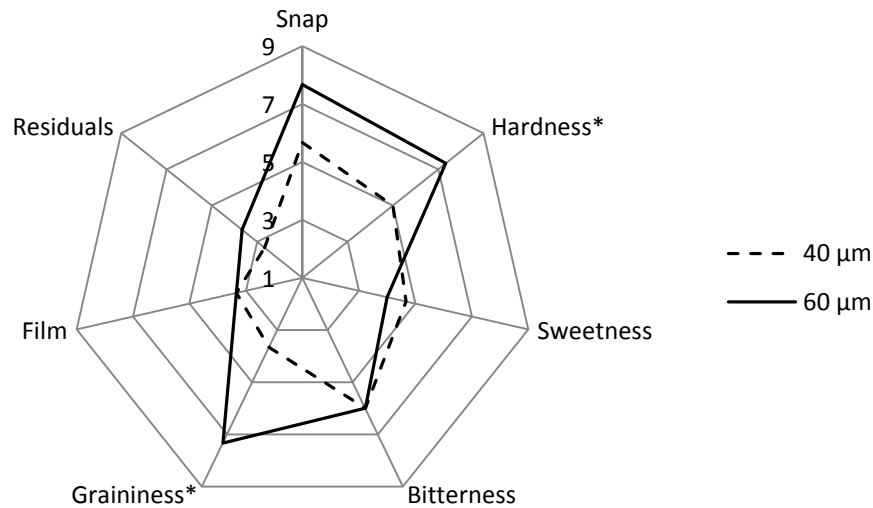


Figure 3. 10: Significant differences for sensory attributes between the 40 µm and the 60 µm chocolates (n=8)

This descriptive analysis confirms the previous results about graininess and about the other attributes except for hardness. This result was unexpected since texture measurements had shown that hardness was not significantly different between those two samples. However, since hardness is influenced by sample thickness and tempering, this last result should be checked with samples of exactly the same thickness and with chocolates coming from different tempering batches.

In conclusion, these sensory experiments have shown that a trained panel is able to perceive a difference of graininess between the 40 µm and the 60 µm chocolates. However, no significant difference of graininess was perceived between the 30 µm and the 40 µm chocolates. Panellists had already encountered the same difficulties during the training even when they knew the Dv_{90} of those chocolates, therefore it can be hypothesized that consumers are not able to indicate a difference in graininess between those two chocolates. Knowing that the trained panel is not able to perceive a difference in graininess although these panellists were selected for their sensory abilities and trained specifically on graininess, it can be assumed that consumers will not be able to perceive a difference as well. An explorative consumer test was performed, to confirm this statement.

3.3.3.3. Sensory analysis with consumer panel

Socio-demographic data

This consumer test was limited as the intention was to conduct exploratory research on this topic. 54 consumers participated in the survey: 36 people in France and 18 people in Ghent. They were 55.6% of females and 44.4% of males. Most of the respondent were between 25 and 65 years old (Figure 3. 11). This study was explorative which explains the rather limited amount respondents. The data from the locations were grouped as no significant differences were found for the data presented.

Acceptance test

Two of the respondents did not complete the questionnaire. Therefore the results of 52 panellists were taken into account for this test. Figure 3. 12 shows that consumers disliked the 60 μm chocolate compared to the other chocolates. Statistical analysis showed that there is a significant difference of acceptance between the 30 μm and 60 μm chocolates ($p=0.030$) and between 40 μm and 60 μm chocolates ($p=0.038$). However, there is no significant difference of acceptance between the 30 μm and 40 μm chocolates. Those results indicate that graininess is an important factor in the acceptance of chocolate. Moreover it confirms the finding that humans are not able to perceive a difference between the 30 μm and 40 μm chocolates. The other tests on the attributes graininess and residuals in the mouth, should be taken into account in order to further confirm this.

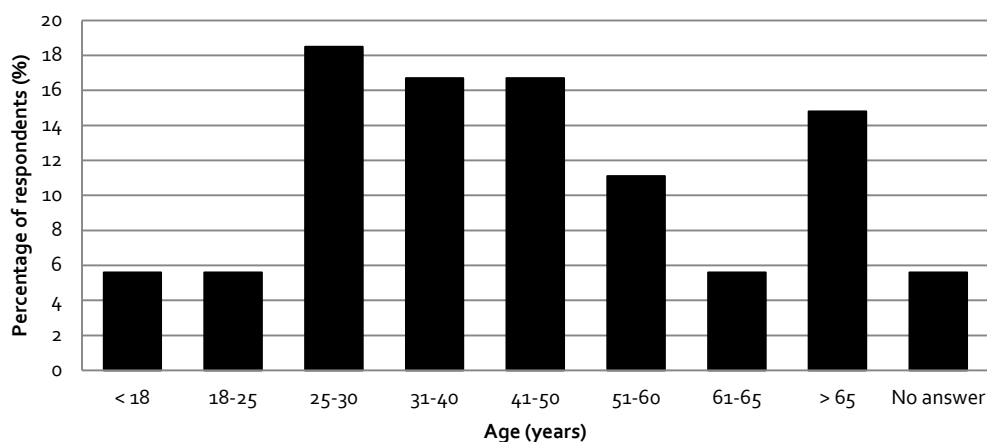


Figure 3. 11: Overview of the age of the respondents

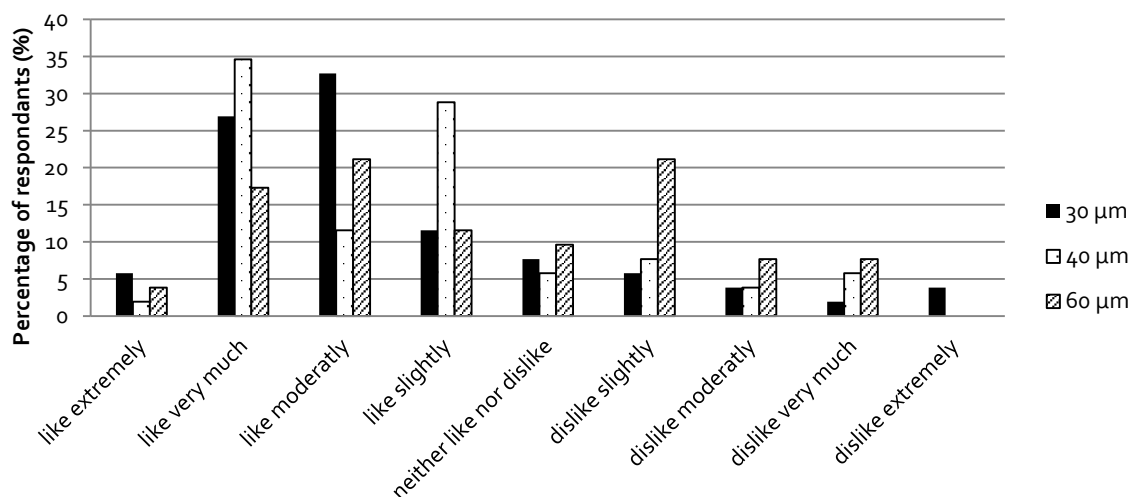


Figure 3. 12: Results of the consumers' acceptance test for the three types of chocolate

Attribute test

Graininess

Figure 3. 13 presents the evaluation of the chocolates on graininess. 59.6% of consumers found that the graininess of the 30 μm chocolate was "just right". This was 44.7% for the

40 μm chocolate and 40.4% for the 60 μm chocolate. Only the 60 μm chocolate was found to be “too much grainy” by some consumers. Unexpectedly, a non-negligible part of consumers found some of those chocolates “not grainy enough” or “really not grainy enough”. This can be due either to a wrong use of the scale or to the fact that some consumers confounded this with aftertaste of the chocolate.

Statistical analyses showed that there is a significant difference of graininess between the 30 μm and the 60 μm chocolates ($p=0.005$) and between the 40 μm and the 60 μm chocolates ($p=0.005$). Those results again confirm that humans are not able to perceive a difference between the 30 μm and 40 μm chocolates.

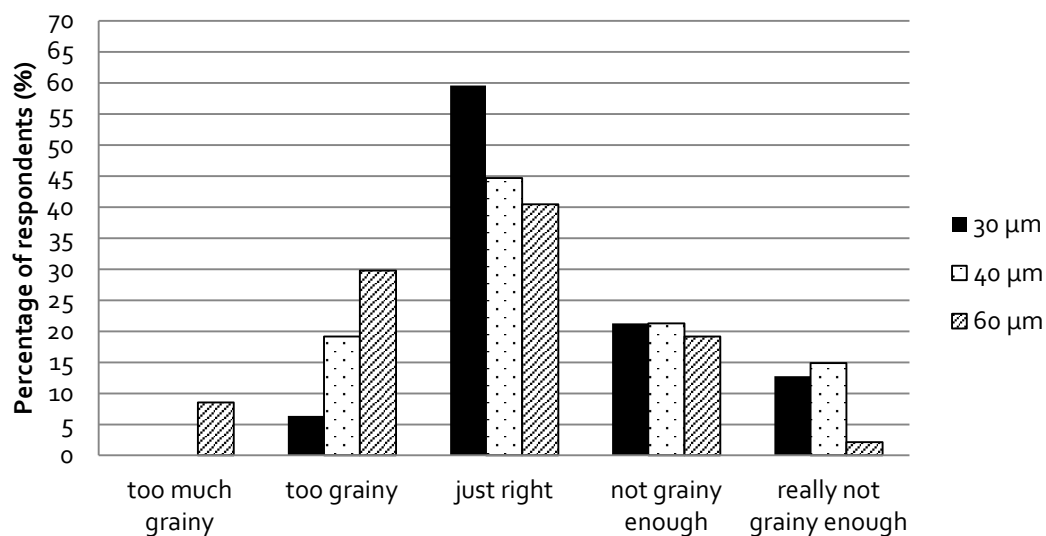


Figure 3. 13: Results of consumers' evaluation for graininess of the three types of chocolate

Residuals in the mouth

Figure 3. 14 shows the results for the evaluation of residuals in the mouth. 47.9% of consumers found that the residuals of the 30 μm chocolate were “just right”. This percentage was 43.8% for the 40 μm chocolate and 52.1% for the 60 μm chocolate. Only the 60 μm chocolate was found to leave “really too much residuals” in the mouth by some consumers. Unexpectedly, a non-negligible part of the consumers found that some of those chocolates had not left enough residuals in their mouth. It is possible that consumers did not fully understand the term ‘residuals in the mouth’ but interpreted it as residual flavour in the mouth. This again points out the importance of using the correct wording, references and definitions in a sensory consumer test (Lawless and Heymann, 2010)

Statistical analyses showed that there is a significant difference of residuals between the 30 μm and the 60 μm chocolates ($p=0.015$) and between the 40 μm and the 60 μm chocolates ($p=0.016$). However, there is no significant difference between the 30 μm and the 40 μm chocolates ($p=0.998$). Those results confirm again the fact that consumers are not able to perceive a difference between the 30 μm and 40 μm chocolates.

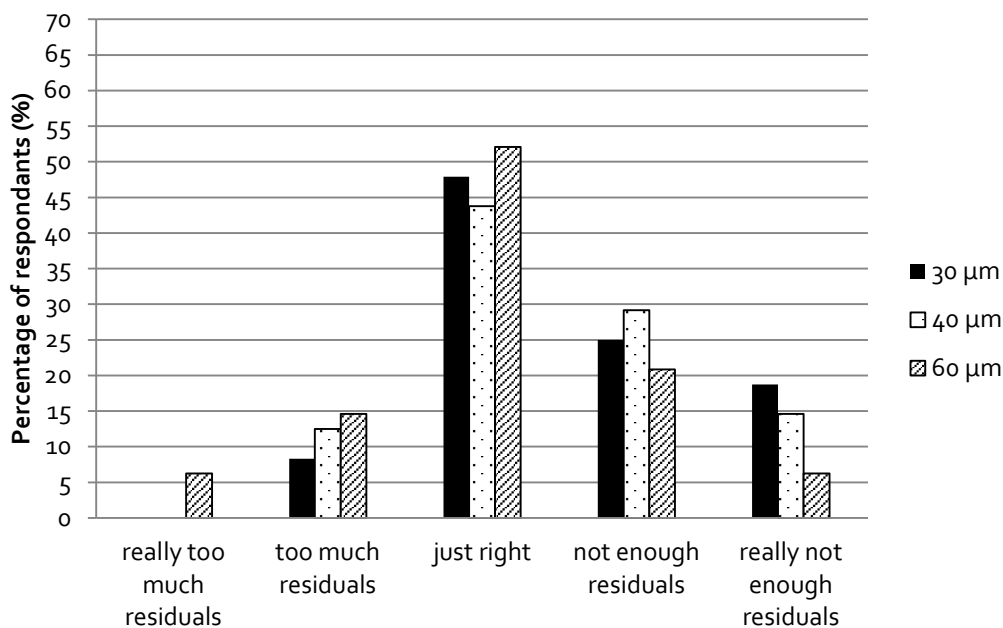


Figure 3. 14: Results of consumers' evaluation for residuals of the three types of chocolate

Ranking test

A total of 85.4% of the consumers were able to rank correctly the 60 µm chocolate (Figure 3. 15). This value is comparable to the value obtained by the trained panel before the training on graininess. However, a non-negligible part of the consumers inverted the 30 µm and the 40 µm chocolates.

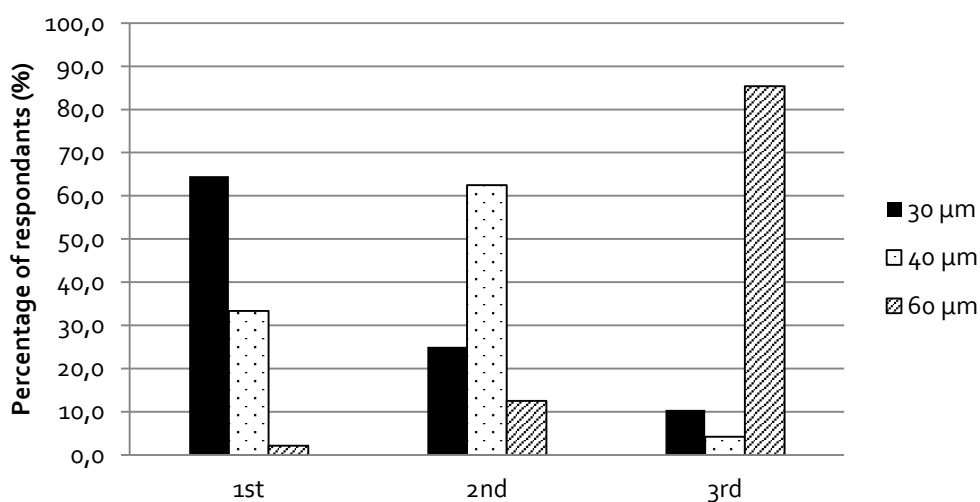


Figure 3. 15: Results of the consumers' ranking test for the three types of chocolate

For statistical analysis, LSD was found equal to 19.2. The differences between rank sums are indicated in Table 3. 10. There is a significant difference between the 30 µm and 60 µm chocolates (66>LSD) and between the 40 µm and the 60 µm chocolates (54>LSD). However, there is no significant difference between the 30 µm and the 40 µm chocolates (12<LSD).

Those results confirm again the fact that consumers are not able to perceive a difference between the 30 μm and 40 μm chocolates.

In conclusion, this consumer test has shown that the 30 μm and the 40 μm chocolates are preferred to the 60 μm chocolate. It has also confirmed that the difference of graininess between the 40 μm and the 60 μm chocolates was perceived by consumers whereas the difference between the 30 μm and the 40 μm was not felt. Contrary to the results obtained with the trained panel, consumers perceived a difference of residuals in the mouth between the 40 μm and the 60 μm chocolates, but not between the 30 μm and the 40 μm chocolates. The consumers are not familiar with the attributes residuals and are therefore confounding this attribute with the aftertaste of chocolate.

Table 3. 10: Differences between rank sums of the three types of chocolate

	Difference between rank sums
Rank sum (40 μm) – rank sum (30 μm)	12
Rank sum (60 μm) – rank sum (30 μm)	66
Rank sum (60 μm) – rank sum (40 μm)	54

3.3.4. Discussion

The results of this study indicate that with instrumental analyses, the PSD of the different chocolates can be defined and that the samples are found to be significantly different. Moreover, the analyses showed that although the aim was to produce a 30 μm , 40 μm and 50 μm chocolate, the latter was not achieved. The production parameters taken from literature resulted in 30 μm , 40 μm and 60 μm chocolates. Therefore, it must be recognized that there is a gap in the results that needs to be filled in future research. Within the restricted time and limited amount of ingredients, it was impossible to produce another chocolate.

The instrumental analyses indicate that although the PSD is significantly different for the three chocolates, this does not influence all the texture characteristics measured with instrumental analyses. DSC measurements showed no significant difference of melting behaviour between the three chocolates. Particle size does not influence melting behaviour in this range of particle sizes. Texture measurements indicated that the 30 μm chocolate is significantly harder than the two other chocolates. Afoakwa et al. (2008b) reported that apparent viscosity and yield stress were more dependent on fat and lecithin content whereas particle size distribution only has a marginal effect. Whenever the PSD is not optimised, there will be a lot of interaction which will lead to a higher viscosity (Do et al., 2007). This can be a topic for future research in a field that is more specialized in microstructure of chocolates. However, this result needs to be taken carefully since hardness is influenced by tempering. Texture measurements should be performed again on chocolates coming from different tempering batches.

The sensory analyses with the trained panel show that the trained panellists were not able to distinguish the 30 μm chocolate from the 40 μm chocolate in the triangle test. The ranking test confirmed this absence of difference between these two chocolates and the ability of the

trained panel to differ those from the 60 μm chocolate. In conclusion, the trained panel was able to detect a graininess that was above 40 μm . However, it is not clear what the exact threshold is. Due to the discrimination tests, the descriptive analysis was conducted with the 40 μm and 60 μm chocolates. Meilgaard (2006) and Stone and Sidel (2004c) indicated that discrimination tests need to be conducted prior to the more extensive, time and money consuming descriptive analyses. If no difference can be detected between studied samples in discrimination tests, it is not useful to conduct descriptive analysis on these samples.

Except for graininess, differences were found for hardness between the 40 μm and the 60 μm chocolates. This could have been due to the fact that sample thickness is not the same for all chocolate samples since they were made manually or to tempering conditions. Therefore, sensory experiments should be conducted with moulded chocolates in order to have a standardized thickness for all the chocolates and with chocolates coming from different tempering batches.

The consumer test indicated that the 30 μm and the 40 μm chocolates were significantly preferred by consumers over the 60 μm chocolate. Similar to the results of the trained panel, consumers were able to perceive a difference of graininess between the 40 μm and the 60 μm chocolates but not between the 30 μm and the 40 μm chocolates. Therefore, the maximum size of chocolate particles that cannot be detected by consumers is equal or higher than 40 μm . Further experiments should be performed with a 50 μm chocolate to determine if this limit is between 40 μm and 50 μm or between 50 μm and 60 μm . Moreover, consumers were also asked to evaluate residuals in the mouth. The 60 μm chocolate was found to leave significantly more residues in the mouth than the 2 other chocolates. No significant difference was found in the results obtained from both locations. This indicates that the perception of graininess in the 60 μm is not limited to the lab context and vice versa, that the difference in graininess is not observed in the lab either.

Both tests on graininess and residuals in the mouth showed that a clear definition of the sensory attribute is necessary when conducting consumer research (Stone et al., 2009). It is impossible to obtain useful data when one consumer interprets an attribute differently from another consumer. For a trained panel, these definitions are found through consensus but in a consumer test the meaning of every attribute should be obvious and similar for all the respondents.

3.3.5. Conclusion

This study is an example of the difference in threshold detection between instrumental analyses and sensory analyses as briefly mentioned in the conclusion in section 3.2.5. Whereas PSD measurements were perfectly able to differentiate the three chocolates, the trained panel was not. When using sensory and/or instrumental analyses in a food company, it is necessary that the researchers are aware of this difference in detection point before making any conclusions on either one of the tests.

The results presented here also show that the differences in PSD in the current samples has little influence on the other texture attributes of chocolate. This is useful information when a chocolate producer would set the cut-off value for PSD higher than the standard of 25 μm to 35 μm used today. It is not unthinkable that the food producer could economically benefit by adjusting the production process in accordance to the results of this study. Given the results of this study, the producer could do this without affecting the overall texture of the chocolate. This could be a topic for future research both for sensory and economic research.

This second study incorporates the voice of the consumer next to the evaluation of the trained panel. Here the aim was to study if a difference between the observations of the trained panel and the consumers was present. Moreover, when sensory research is conducted, it is useful to incorporate the acceptance or preference of the consumer. This is specifically true when the research is done to find possibilities for either product or process innovation. As will be illustrated in part 2 and 3 of this doctoral research, the consumer always has an influence on the final product. As a food producer and even as a sensory researcher, this is something to be aware of.

3.4. Study 3: Influence of milk chocolate sensory attributes on Belgian consumer's affective ratings

3.4.1. Introduction

Cocoa products and chocolate are known throughout the world as products that provide instant enjoyment and pleasure. Chocolate is one of the most popular examples of foods which are consumed during comfort eating (Paoletti et al., 2012). Moreover, it can lead to elicited joy associated with sensory pleasure (Macht and Dettmer, 2006). Research has determined that the hedonic appeal of chocolate is based on appearance, colour, texture and taste or flavour but also on memories of past chocolate experiences.

Jovanovic & Pajin (2002) stated that chocolate quality depends on structure, processing techniques and ingredient composition as these factors influence the physical properties and sensory perception of chocolate. From all the different sensorial attributes, texture is a very important characteristic of food. Although Afoakwa (2010) mentioned that flavour is the most important factor that determines the acceptance and preference for chocolate products, for some people texture is more important than taste (Andrae-Nightingale et al., 2009). A descriptive study on milk chocolates showed that little differences were found for the aroma descriptors but that the chocolates were differentiated based on taste and texture in the mouth (Dürschmid et al., 2006). Moreover Torres-Moreno, Tarrega, Torrecasana & Blanch (2012) concluded that consumer acceptance of dark chocolates depends not only on brand or type of chocolate but mostly on the sensory characteristics of the product. Consumers base their overall liking and food choice on their sensory perception and sensory properties (Torres-Moreno et al., 2012). Afoakwa (2010) explicitly noted that texture plays an important role in the sensory assessment of chocolate. In line with these findings, this study explores how sensory characteristics and specifically texture attributes affect the overall acceptance of the chocolate samples.

This research focuses on the influence of chocolate sensory characteristics and specifically texture on acceptance. Chocolate texture is defined by the ingredient composition (Afoakwa et al., 2007), solid particle size distribution and ingredient composition. These characteristics can be manipulated to modify the physical properties, rheological behaviour and sensory texture attributes (Afoakwa et al., 2007). Understanding the characteristics of chocolate texture and other sensory characteristics and its impact on general acceptance is important. A company can use the knowledge to differentiate themselves from other competing brands, as well as to strengthen their own brand message (Thomson et al., 2010). This can be an opportunity for the food or sensory scientist and the marketer to work synergistically to gather actionable product insights and craft a better positioned product in the ever-changing global market.

The overall objective of the present study is to examine the influence of the sensory characteristics and specifically texture of milk chocolate on Belgian consumers' affective ratings (e.g. overall acceptance and attribute liking of chocolate). First, the physical characteristics of selected brands of chocolates are determined through instrumental analyses. Next, the sensory profile of these samples is constructed by a trained panel using Quantitative Descriptive Analysis (QDA). Finally, the acceptance of the consumers is tested in a consumer test conducted at the UGent SensoLab.

3.4.2. Materials and methods

3.4.2.1. Sample information

The three milk chocolate samples were purposely selected because of their apparent sensory differences. These samples also represent three 'segments' of chocolate products in Belgium: chocolate from premium brand (PB), a chocolate available under private label (PLB) and a traditional type of chocolate which is originally produced and originated in Belgium (TB). It should be noted that the term 'traditional' does not refer to 'handmade'. The chocolate used in this study for TB is industrially manufactured (Table 3. 11).

Table 3. 11: Ingredient list of the commercial samples

Chocolate	Ingredients in the label
Premium Brand (PB)	Sugar, cocoa mass, whole milk powder, cocoa butter, whey powder (from milk), emulsifier (soy lecithin), low fat cocoa powder, flavouring, milk fat. Cocoa: at least 33%
Private Label Brand (PLB)	Sugar, whole milk powder, cocoa mass, cocoa butter, lactose, emulsifier (soy lecithin), flavours. Cocoa: at least 32%
Traditional Brand (TB)	Sugar, hydrogenated vegetable fat, lactose, low fat cocoa powder, low fat milk powder, calcium carbonate 3.5%, dextrose 2% emulsifier (soy lecithin), stabilizer: E492, flavours

The three milk chocolates were purchased in local supermarkets in Ghent (Belgium) on the same day that each of the experiments were conducted. As all the chocolates are produced industrially, the quality of each brand is assumed to be constant among different batches. It was assumed that the producer of the private label chocolate did not change during the short period of time in which the chocolates were purchased for the experiment (4 weeks). It is noteworthy that the TB from Belgium is labelled as "chocolate flavoured bar" since it contains hydrogenated vegetable oil which is partial substituted to cocoa butter that is beyond the maximum allowed by the European Union (Directive 2000/36/EC).

3.4.2.2. Instrumental measurements

Colour measurement

Colour was measured as described in section 1.6.1.2. Colour measurement was done in triplicate in different chocolate bars for the three samples. The mean values for these replicates are used for further analysis.

Penetration test

Hardness was measured by determining the maximum penetration force for chocolate (section 1.6.1.2) using the program as described in section 2.2.3.2. The measurements were repeated 10 times on each type of chocolate bar. Again, the mean values were used for further analysis.

Determination of melting properties of chocolates

The melting profile of the chocolate samples was determined using the DSC measurement (section 1.6.1.2). The procedure as described in section 2.2.3.4 is used. Analysis was carried out in triplicate. Mean values and standard deviations reported and used for further analysis.

3.4.2.3. Determination of the sensory profile of chocolate

Sensory profiling of chocolates was conducted using quantitative descriptive analysis (QDA). Descriptive analysis is composed of the following phases: 1) a qualitative, lexicon generation process; and 2) a quantitative set of sensory tests designed to quantify on a rating scale the intensity of the sensory terms established in the lexicon generation phase. Descriptive analysis was performed in the UGent SensoLab in.

Qualitative phase of QDA: Generation of descriptors and score sheet development

The trained chocolate panel (n=8) of the UGent SensoLab was asked to list attributes related to each of the three samples of milk chocolate in terms of appearance, aroma, texture and taste. The final terms (n=15) that were retained were integrated into a score sheet and were used for the evaluation (Table 3. 12). This covers appearance (n=2), aroma (n=4), taste (n=2) and focused on texture (n=7). After a discussion phase, an agreement among the panellists was made on the final procedure to use for product sensory evaluation.

Quantitative phase of QDA: Product evaluation of milk chocolate

Each chocolate tablet was cut into approximately 15 g pieces crosswise 15 min before serving. The samples were equilibrated for 5 min to room temperature (20°C) as suggested by Torres-Moreno et al. (2012) and served in small disposable plastic plates. Samples were coded with a 3-digit random number and were given to the panellists, one at a time, in a unique randomized order to avoid bias. They were asked to evaluate the samples using the developed score sheet and in terms of the descriptors that were generated during the qualitative phase of the QDA. The panellists were asked to quantify the intensities of each of the attributes of the milk chocolates using a 15 cm unstructured scale. To decrease the level

of fatigue and to clear their palate, panellists were given still mineral water in plastic cups and crackers. The panellists evaluated the samples for three times in three different sessions.

Table 3. 12: Attributes used by the trained panel to evaluate the chocolate samples

Attribute	Definition
<u>Appearance</u>	
Brown Colour	The intensity of brown colour from light to dark brown
Gloss/ Surface shine	Luminescence of colour, with descriptions ranging from dull to shiny.
<u>Aromatics</u>	
Cocoa aroma	The aromatic associated with cocoa powder
Caramel aroma	The aromatic associated with caramelizing sugar without burning it
Vanilla aroma	The aromatic associated with vanilla or vanillin
Milky aroma	The aromatic associated with fresh or pasteurized milk
<u>Taste</u>	
Sweet Taste	The taste on the tongue associated with sucrose (sugar)
Bitter Taste	The taste on the tongue associated with caffeine
<u>Texture</u>	
Snap	The noise and force with which the sample breaks or fractures
Hardness	The force required to compress the chocolate
Graininess/ Grittiness	The amount of solid particles during mastication
Creaminess	The mouth-feel related to the smoothness of the chocolate as related to fat
Rate of melt	The amount of time it takes to melt the chocolate in the mouth
Oily/ greasy film	The amount of oil left on mouth surfaces
Residual	The amount of solid particles left in mouth after swallowing

3.4.2.4. Consumer Testing

Consumers who served as respondents in this study were randomly recruited at Ghent University. Eligibility for selection was based on the criteria as suggested by Meilgaard, Carr & Civille (2006): (1) regular consumers of chocolate; (2) do not have a specific disliking for chocolate; (3) do not have any known food allergies or dietary intolerance; (4) willingness and availability to participate in the study. As part of the participant recruitment, information on demographics and patterns of chocolate consumptions were collected through a questionnaire after the chocolate evaluation. A total of 131 respondents participated in the study at the SensoLab.

Respondents were seated in individual booths. They were given a brief instruction about the procedure of the test. The chocolate samples were randomised and were presented monadically. The labels and brands of the chocolate samples were removed and the chocolates were placed on plastic plates with random 3-digit codes before serving to the respondents. The preparation was executed 10 minutes before the evaluation to avoid prolonged exposure to air and environment. The respondents received table napkins and were encouraged to drink some still mineral water in between samples to cleanse their palate and have some rest. The average time for a respondent to complete the evaluation was 10 minutes.

The questionnaire was composed of two parts. First, the respondents were asked to taste the chocolate and rate their overall liking for each product, using a nine-point hedonic scale (Lawless and Heymann, 2010). Second, they were asked to indicate in a 'just about right' (JAR) scale their perception of the texture attributes of the chocolate.

The study was conducted in the UGent SensoLab. Part of the results (JAR scores for sensory attributes) were used in this chapter, whereas the results related to sensory profiling, which was conducted with the EsSense Profile® method (King and Meiselman, 2010) were reported in chapter 5. This method will also be explained in section 5.2.1.4.

3.4.2.5. Statistical Analysis

Instrumental Analysis

Penetration test data (hardness), and peak melting (T_{peak}) from DSC were analysed using analysis of variance (ANOVA). When significant differences were found, Tukey HSD post-hoc test was used to determine where the differences occurred. Significance of the differences were defined at $p < 0.05$. Kolmogorov-Smirnov test for normality and Modified Levene tests were performed to check if assumptions related to ANOVA were fulfilled.

QDA and overall acceptance

After the evaluation, the results were decoded. Scores marked by the panellists on the rating scales were measured in centimetres from the left to the right end of the scales. Data obtained from each panellist were recorded as a product-attribute matrix. Analysis of variance (ANOVA) was used to determine if there were significant differences for sensory attributes and overall liking of chocolates by means of SPSS statistical package (SPSS Inc., Chicago, IL, USA). When significant differences were found, Tukey HSD post-hoc test was used to determine where the differences occurred. Significance of the differences were defined at $p < 0.05$.

3.4.3. Results

3.4.3.1. Characterization of the chocolate samples

Instrumental measurements

Colour measurement

Significant differences were found among the three samples in all colour parameters. PLB was significantly lighter ($L = 37.01$; $p < 0.05$) than PB (33.70) and TB (33.30). These values correspond to the findings of Popov-Raljić and Laličić-Petronijević (2009) on their study of milk chocolates where they found lightness values that range from 31.50 to 36. Positive values in the 'a' axis denote that the all samples are closer to the red space rather than the opposite green. TB was significantly highest (12.50) and different from the other chocolates. The overall colour of TB was different from the other chocolates, whereas the PLB was found to be lighter than TB and PB.

Penetration test for hardness

Significant differences are found among the three samples in terms of hardness. The results indicate that PB is the hardest (8.09 N) followed by PLB (7.35 N) and TB (5.67 N). All the samples are significantly different ($p < 0.05$) from each other.

Determination of melting properties of chocolates

The melting profiles of the three chocolate samples is presented in Table 3. 13. PB shows a single peak which may indicate that there is only one type of fat (cocoa butter) present in this chocolate. On the other hand, both TB and PLB show two peaks (one big and one small) which may suggest the presence of more than one type of fat or fat polymorph present in the chocolate (Beckett, 2000). Significant differences were found for peak surface and final melting point.

Table 3. 13: Mean values and standard deviation of DSC parameters (Tonset, Peak surface, Final melting point, Peak width) for PB, PLB and TB (n=3)

	T Onset (°C)	Peak surface (J/g)	Final melting point (°C)	Peak Width (°C)
PB	29.4±0.0 ^a	34.0±3.0 ^a	32.4±0.4 ^a	4.1±0.0 ^a
PLB	30.7±0.9 ^a	29.4±0.0 ^a	32.6±0.1 ^a	3.6±0.3 ^a
TB	30.5±1.4 ^a	19.0±1.0 ^b	33.7±0.2 ^b	4.0±0.4 ^a

^{a,b} presents significant differences between mean values within the same column

Determination of the sensory profile chocolate

Twelve out of the 15 used attributes are discriminators between the different chocolate products (Table 3. 14). This implies that the trained panel can find differences in sensory attributes of the chocolate samples through QDA.

Table 3. 14: Mean intensity scores of the chocolate samples on the different sensory attributes by QDA ®

Attribute	Premium brand	Private label brand	Traditional brand
Colour	9.6 ^a	6.0 ^b	4.4 ^c
Gloss	9.6 ^b	7.6 ^c	10.7 ^a
Cocoa aroma	9.1 ^a	7.2 ^b	4.7 ^c
Caramel aroma	4.5 ^b	5.8 ^b	6.5 ^a
Vanilla aroma	3.3 ^a	4.5 ^a	4.6 ^a
Milky aroma	4.6 ^{b,c}	6.1 ^{a,b}	6.6 ^{a,b}
Snap	9.5 ^a	7.3 ^a	6.3 ^b
Hardness	8.7 ^a	7.8 ^a	4.4 ^b
Sweetness	8.6 ^a	9.8 ^a	10.0 ^a
Bitterness	4.7 ^a	1.7 ^b	0.9 ^b
Grittiness	2.7 ^b	3.2 ^b	8.4 ^a
Creaminess	9.2 ^a	8.9 ^a	6.3 ^b
Rate of melting	6.5 ^a	7.5 ^a	7.6 ^a
Oily film	8.7 ^a	7.8 ^a	4.4 ^b
Residual	3.2 ^b	3.3 ^b	6.7 ^a

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

Appearance, aroma and taste attributes

Significant differences for brown colour and gloss were found among the three samples. PB had a significantly more intense brown colour than PLB and TB had the least intense brown colour. TB had the highest mean score for gloss which was significantly higher than for the other two samples. PB obtained the lowest mean score for gloss.

PB had the highest mean score for cocoa aroma which was significantly different from PLB and TB. TB had the highest intensity of caramel aroma which was significantly different from the other two samples. The three samples were not significantly different in terms of vanilla and milky aroma and sweetness.

PB was rated to have the highest intensity of bitterness which was significantly different from PLB and TB. These two samples did not differ significantly from each other in terms of bitterness and it should be noted that they had very low intensity of bitterness.

Textural attributes

PB obtained the highest mean hardness intensity which was not significantly different from PLB. TB was evaluated as significantly less hard than the other two samples. The same trend was observed for the attribute snap. PB had the highest mean intensity of snap which was not significantly different from PLB. TB had significantly lower snap mean score than the other samples.

TB obtained the highest mean score for grittiness which was significantly higher than PLB and PB which had very low scores. Grittiness is a more common term to describe geometrical characteristics such as particle shape and size which can be felt in the mouth. Creaminess was defined by the panellists as the smoothness of the mouth feel of the chocolate due to fat. PB and PLB had a significantly higher intensity of creaminess than TB.

The three samples were not significantly different in terms of melting rate. This refers to the dynamic (i.e., time-dependent) aspect of food breakdown. In terms of oily film formation in the mouth PB and PLB did not differ significantly but these mean scores are significantly higher than the mean value of TB. TB had the highest intensity of residuals which was significantly higher than PB and PLB. Residuals were defined by the panellists as the amount of solid particles left in the mouth after swallowing. This attribute is somewhat related to grittiness for which TB also had the highest intensity.

Correlation of instrumental and sensory attributes

Correlations between instrumental and sensory characteristics were studied. Instrumental hardness measurement has a medium, positive correlation ($r=0.4$) with bitterness which was statistically significant ($p<0.05$). Further, there was a strong, positive correlation between melting temperature and milky aroma, which was statistically significant ($r=0.7$, $p<0.05$) as well as gloss ($r=0.8$, $p<0.05$). Sensory attributes with significantly ($p<0.05$) strong, positive correlations are cocoa aroma and bitterness ($r=0.9$), residuals and grittiness ($r=0.7$) and oily/greasy film and creaminess ($r=0.8$). Instrumental hardness did not correlate strongly with

sensory hardness which was expected although sensory hardness correlated well with snap ($r=0.9$).

Principal component analysis was done to visualize and summarize the relationships of the sensory attributes and instrumental measurements (Figure 3. 16). The first and second principal components (PC) explained, 30.23% and 21.54%, respectively, of the observed variation. PC₃ added an additional 19.03% to the explained variance. Together this explains more than 70% of the variance. This is a good value, taken into account that not all sensory characteristics are taken into account. Bartlett's test of sphericity was significant, indicating that the correlation matrix is not an identity matrix and that principal component analysis can be applied to the data. Cocoa aroma, bitterness, oily film formation, caramel aroma and creaminess contributed to explain the variance of PC₁, while gloss and sweetness explained the variance of PC₂.

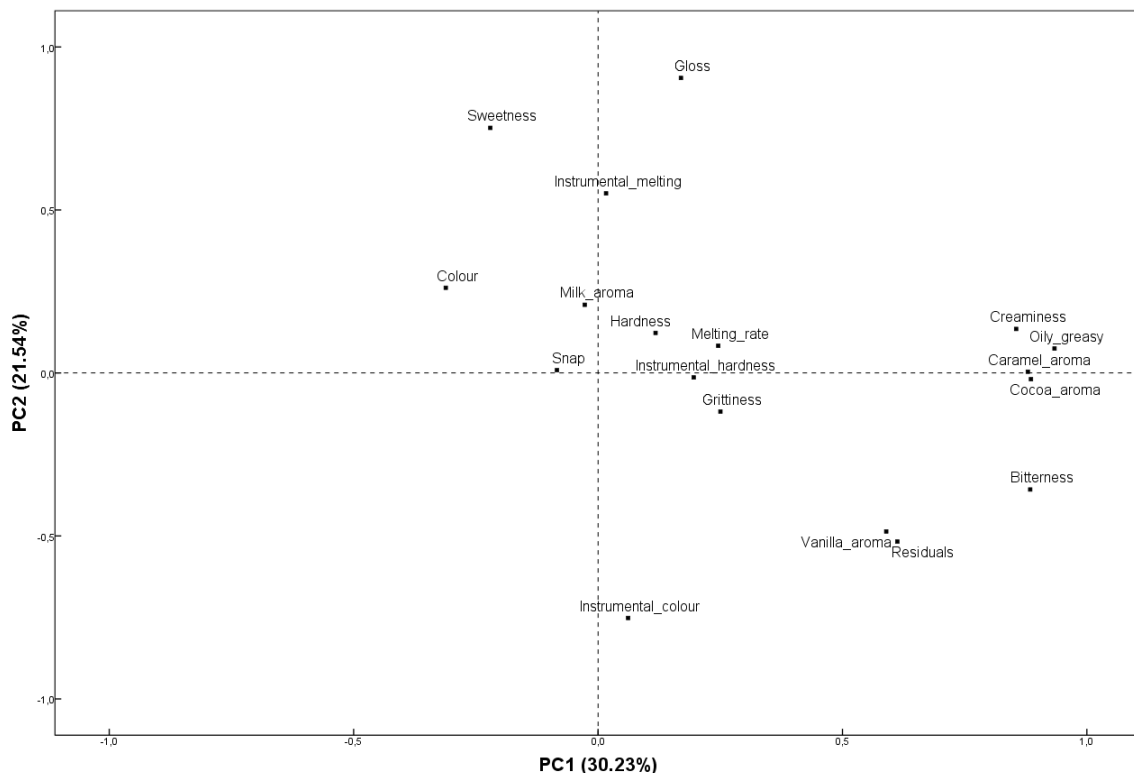


Figure 3. 16: Principal component analysis for sensory and instrumental data (PC₁: 30.23%; PC₂:21.54%; PC₃:19.03%)

3.4.3.2. Consumer Testing

Socio-demographic characteristics of respondents

From the 131 respondents who participated in the consumer test in the SensoLab, 127 completed the questionnaire. The incomplete questionnaires were eliminated from the dataset. The consumer sample was composed of 70 (55.1%) females and 57 (44.9%) males. As these consumers were recruited at Ghent University, 92.1% of the respondents are between the age 18-25 followed by 3.2% between 26-30 years old. Similarly, the majority are students (88.9%). More than half of the respondents (57.9%) prefer milk chocolate followed

by those who prefer dark chocolate (27.8%) and finally those who prefer white chocolate (13.3%).

Overall acceptance

Based on all respondents, PB scored significantly higher (6.9) in overall acceptance compared to PLB (6.2) and TB (4.7). When grouping the respondents based on their chocolate type preference (white, milk or dark), as milk chocolates were used in this experiment, all the respondents who indicated that they prefer milk chocolate were grouped together (n=73) and the respondents that preferred other types of chocolate were grouped (n=53). The same trend for overall acceptability (PB>PLB>TB) was found for respondents who prefer milk chocolate and those who prefer other types (dark and white). For each type of chocolate, the two groups did not differ in the level of their liking for PB, PLB and TB. The acceptability of the three chocolate did not differ between male respondents (n=56) and female respondents (n=70). Moreover, same trend for overall acceptability (PB>PLB>TB) was found for male and female respondents. Thus, acceptability for each type of chocolate was not influenced by gender or the type of chocolate they prefer.

Just about right (JAR) data

Figure 3. 17 shows the distribution of the Just-About-Right (JAR) scores for texture (hardness) of the three chocolate samples. TB is perceived by a majority of the respondents (62.7%) to have a too soft texture and its 'just about right' score is rather small (19.1%). In contrast, PB obtained the highest JAR score among all the samples (67.5%) which is indicative of an optimum level of hardness. PLB (58.7%) has a JAR-score that is somewhat lower than the score for the PB chocolates. The JAR scores from the consumer panel confirms the results of both the instrumental and QDA hardness evaluation. In both instrumental and sensory tests, PB obtained the highest scores for hardness which is significantly different from the other two samples. On the other hand, TB had the lowest hardness intensity.

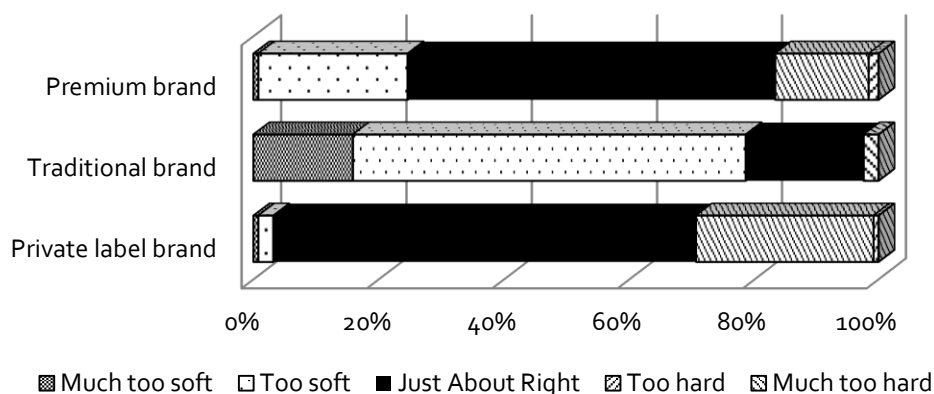


Figure 3. 17: Distribution of the JAR scores for hardness of the chocolate samples based on the question: "What do you think of the texture of this chocolate?" (n =127)

3.4.3.3. Relationship of overall acceptance and sensory characteristics

The PLS regression is the most appropriate multivariate regression method available to find a function of the predictive variables (here sensory characteristics) that best describe the variation in the hedonic data (Meullenet et al., 2007). Partial Least Square regression (PLSR) was performed on the QDA and overall acceptance data to determine the 'drivers of liking'. Figure 3. 18 depicts the weighted regression coefficients and the confidence intervals for these coefficients. Some confidence intervals are wide and include zero. This indicates an overfitting problem what means that it includes random noise in the specific samples. This overfitting may be due to the large number of variables (15 emotions) (Meullenet et al., 2007). This can be improved by selecting a priori the most important emotions only to reduce the number of predictors and obtain a better fit. But with the current output, at least we see the influence of all the 15 sensory characteristics. The weighted regression coefficients (WRCs) indicate the role of a variable in the prediction of overall liking. Variables with positive WRCs are referred to as positive drivers of liking while variables with negative WRCs are usually referred to as negative. Weighted regression coefficients (Figure 3. 18) shows that positive 'drivers of liking' are colour, cocoa aroma, snap, hardness, bitterness, creaminess and oily-film formation. On the other hand, the negative drivers of liking are 'absence of gloss', 'caramel aroma', 'intense sweetness' and 'milky aroma', 'grittiness' and 'residuals' which are all present at high levels in TB.

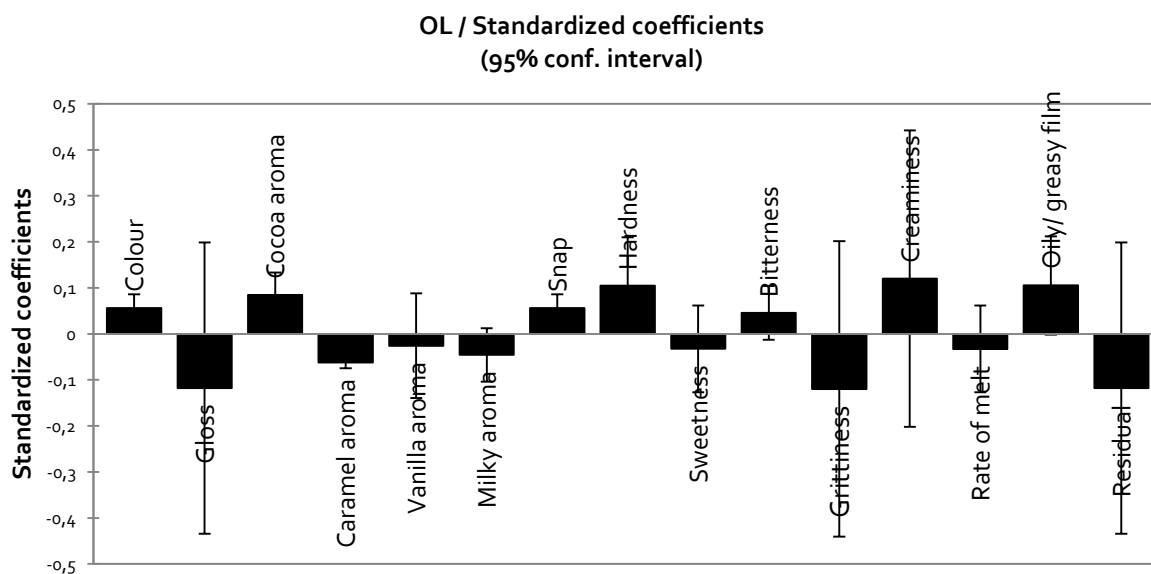


Figure 3. 18: Weighted regression coefficients for sensory attributes predicting overall liking of chocolates based on Partial Least Square Regression

3.4.4. Discussion

This research aimed to determine the influence of chocolate texture on Belgian consumers' emotions and affective ratings. The relationship of sensory attributes and especially texture with the acceptability of the chocolate samples were studied.

3.4.4.1. *Instrumental analyses*

This difference in hardness of the three chocolate samples may have been caused by the ingredient formulation and manufacturing techniques (Beckett, 2000). Moreover, Liang & Hartel (2004) explained that milk powders with different free milk fat content are expected to have an influence on chocolate hardness. Guinard & Mazzucchelli (1999) showed that hardness of chocolate is correlated with sugar and fat levels. Afoakwa, Paterson, Fowler & Vieira (2008c) found that hardness decreased as particle size increased irrespective to state of tempering.

In terms of the results of the DSC, differences in peak widths are apparent which reflects the variation in melting properties and crystallization as proposed by McFarlane (1999).

For TB, this may be due to the partial substitution of fat other than cocoa butter that is beyond the maximum allowed by the EU. Thus, in a more technical classification, TB is labelled as "chocolate flavoured bar". Such information is relevant for the sensory characteristics and impact on mechanical and rheological properties of chocolate and confectionery shelf life (Hartel, 2001). Hydrogenation reduces double bonds to single bonds, which increases both melting point and stability of the oil and thus raises the melting temperature (Schmidt et al., 1996). The melting temperatures of PB and PLB are within the range of melting point for cocoa butter namely 29°C to 34°C for the β V form as stated by Van Malssen, van Langevelde, Peschar, & Schenk (1999).

3.4.4.2. *Quantitative Descriptive Analysis*

Samples were clearly differentiated in most attributes. PB had more intense brown colour, cocoa aroma, snap, hardness, bitterness and oily formation while TB had highest gloss, caramel aroma, grittiness and residuals but lowest in brown colour, snap, hardness, bitterness and oily film. PLB had no distinct sensory attributes, as the values for these attributes are mostly between premium and traditional brand chocolates.

The indicated differences can be attributed to the higher amount of cocoa mass described on the label of the PB sample (at least 34%) than on the label of the PLB sample (at least 32%), which thus produced a darker appearance (Full et al., 1996).

Gloss relates to the capacity of a surface to reflect direct light at the specular reflectance angle with respect to the normal surface (ASTM, 1995). The high gloss score of TB may be due to its different fat content (hydrogenated vegetable fat). The fat phase has the greatest influence on chocolate properties such as snap and gloss (Beckett, 2009).

Cocoa aroma is a function of the amount of chocolate mass in the formulations (Guinard and Mazzucchelli, 1999) which is in congruence with the information on the labels of the chocolates.

Caramel aroma is influenced by the sugar content and to a lesser extent by fat and milk solid levels (Guinard and Mazzucchelli, 1999). Bitterness in chocolate is mainly due to the caffeine and theobromine which are naturally occurring in cocoa beans (Beckett, 2000).

The QDA results for texture are in congruence with the instrumental texture analysis for hardness which showed a similar trend. These differences may be primarily due to the differences in the ingredient formulation and manufacturing techniques as suggested by Beckett (2000). Hardness is related to forces of attraction between particles of food that oppose disintegration (Muñoz et al., 1992) and reaction of the food to applied stress (e.g. by chewing between the teeth).

Grittiness which is the perception of organized structures of different geometrical arrangements within the product (Muñoz, 1986) is greatest in TB. This may suggest that the particle size of TB is higher than 40 µm (Study 2) since grittiness was detected by the panellists (Beckett, 2000).

Creaminess, which is a combination of taste and mouth feel, is lowest in TB. This can be attributed again to the partial replacement of cocoa butter with hydrogenated vegetable oil in TB. The different fatty-acid composition may have affected the perception of creaminess. In dairy products, creaminess is linked to milk fat globules (Frøst and Janhøj, 2007). On the other hand, the panellists seemed to have some difficulty in evaluating the rate of melt since the DSC results for melting showed that TB had a significantly higher melting temperature than the other two samples but this difference was not confirmed in the QDA. Melting may have also been influenced by the rate of chewing of the panellists although they were instructed to let the chocolate melt on their tongue.

In terms of oiliness, TB again had the lowest mean score. Oiliness refers to a secondary term to describe fat content in the product (ASTM, 1992a). It is one of the sensory properties that correlates most with creaminess irrespective of product type (Frøst and Janhøj, 2007). As such, the oiliness scores were in congruence with creaminess.

The QDA of the chocolate samples supported the findings of Vitova et al. (2009) that milk chocolate with replaced vegetable fat was different in all sensory parameters. In this study, TB which had a different type of fat compared to the other samples, was found to be inferior in terms of all the textural attributes (hardness, snap, grittiness, creaminess and residuals).

3.4.4.3. *Sensory-instrumental correlations*

Strong, positive correlations were found between sensory attributes such as cocoa aroma and bitterness, residuals and grittiness, and oily/greasy film and creaminess which were expected since these are related sensory attributes. However, instrumental hardness did not correlate strongly with sensory hardness which was expected although sensory hardness correlated well with snap ($r=0.9$). In their study of dark and milk chocolates, Andrae-Nightingale et al. (2009) reported highest correlation between instrumental texture and sensory texture properties. Principal component analysis showed that cocoa aroma, bitterness, oily film formation, caramel aroma and creaminess were closely correlated. Proximity of instrumental hardness to the sensory attribute snap indicates strong correlation.

Similarly, Andrae-Nightingale et al. (2009) also found that fatty mouth-coating (oily film formation) and shiny (gloss) had the highest contribution to PC1 and PC2.

3.4.4.4. *Consumer testing*

The highest acceptability score of PB may be attributed to the just-about-right levels of its sensory attributes as revealed by the trained panel. Focusing on texture, the significantly lower grittiness and residuals in the mouth of PB and the higher intensity of snap of this sample compared to TB especially may account for the higher acceptance score. Although PB had the highest hardness intensity, majority of the consumers find this to be "just about right". This can be related to what Tuorila (1996) calls the "*hedonic optimum*" or the best liked concentration or level of a particular attribute which varies among foods and across cultures.

Afoakwa (Afoakwa, 2010, Afoakwa et al., 2007) mentioned that it is desirable for a chocolate to be a firm solid product with a good snap and a smooth mouth feel. Thus, it can be confirmed that overall acceptance of chocolate samples used in this study is influenced by differences in texture. It should, however, be mentioned that since food according to Lawless and Heymann (2010) is a multi-modal experience, the sensations from one sensory modality may influence judgments and perceptions from another, and as such, the overall acceptance may also be influenced. Therefore, although the textural characteristics of the PB chocolate may have influenced its acceptance, the other distinguishable sensory characteristics such as colour, cocoa aroma, caramel aroma and milky aroma also have an effect. As such, the positive drivers of liking identified by PLSR which include colour, cocoa aroma, snap, hardness and oily-film formation are all JAR in the premium brand. Negative drivers of liking namely caramel aroma, grittiness and residuals are intense in the traditional brand.

3.4.5. Conclusion

This study shows that the combination of instrumental analyses and sensory analyses, with trained panel and consumers, are valuable to get complementary information on which characteristics are drivers for the consumers' acceptance of a chocolate product.

The consumer test revealed that premium brand was the most accepted sample, followed by private label brand and traditional brand. Analysis of the relationship between sensory attributes and overall acceptance showed that textural characteristics such as hardness, snap, oily-film formation were positive drivers of liking while grittiness and residuals influenced overall acceptance in a negative way. However, since differences in other sensory characteristics like colour, aroma and taste were also established, the overall acceptance of the chocolates cannot be solely attributed to the influence of texture since food perception is a multi-modal experience. Nevertheless, this study is already a first step in exploring how sensory characteristics and overall acceptance are interrelated which, if harnessed effectively, can offer interesting insights which can be used for competitive marketing in the chocolate industry.

3.5. *General Conclusion*

All three studies indicated that instrumental analyses and sensory analyses can help in getting insights on product quality, define options to change processing conditions without interfering with consumer experience and consumer acceptance. More important, these studies pointed out that the first step is always to define what needs to be measured or to determine which question needs to be answered. Is it defining a standard parameter for the production of a product? Is it finding differences that can be tasted by consumers? The range of questions is endless and all of them need a specific approach. For some of these questions, it is sufficient to use either instrumental analyses or sensory analyses. In most cases the combination of both will create an insight that can be valuable to the product optimisation and therefore to the final market success of the product. However, the three studies captured some critical points that every researcher should take into account when conducting an experiment.

The first study highlighted the difference in product handling in instrumental analyses and sensory analyses. For instrumental analyses, only parts of the product are subjected to the analyses, whereas in the latter the complete product is used. This can cause differences in the evaluation of the product which are not due to the product. In the past, some scientists have pronounced their favour for sensory tests with a trained panel as the use of the complete product is closer to the reality in which a consumer will handle the complete product and thus will have a more complete experience.

Further this first study already points out the importance of threshold values or detection points (Figure 3. 19). The reality is that a gap on the measuring scale exists between what a machine can detect and what an individual can detect. Moreover, this difference in threshold also exists between a trained panellist and a normal consumer. When asking a question which is related to the consumer, it is crucial to choose the measuring tool that has a threshold closest to the one of the consumer. Sometimes this is the instrumental measurement and sometimes the evaluations of a trained panel. This difference in detection point is also clear in the second study on particle size distribution (Figure 3. 19).

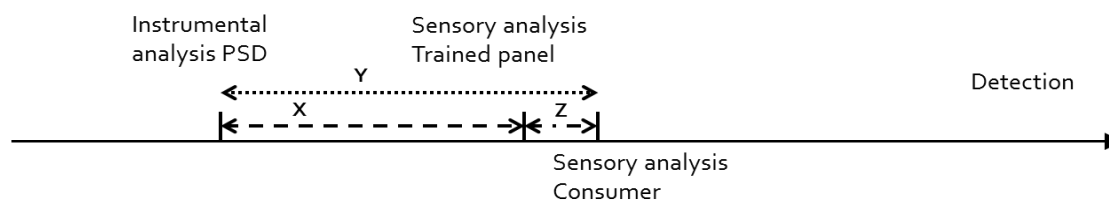


Figure 3. 19: Example of difference in detection point of PSD/graininess between instrumental analysis, sensory analysis with trained panel and sensory analysis with consumer panel

However, when the two methods are combined, which is done in most of the studies, complementary information is gained. This is also illustrated in the second study. Here, it is shown that the different PSD does not influence the other texture characteristics of

chocolate. Moreover, the explorative study that was conducted with consumers, showed that these differences were also not observed during consumption. This opens a window of opportunities for chocolate producers to start experimenting with the production of a chocolate with a larger PSD distribution. Therefore, possibilities for product and process innovation can be found at the intersection of instrumental analyses and sensory analyses. By closely studying results of these analyses, new insights can be gained for the benefit of the company, consumer or even researcher. Further, this study also indicated the importance of performing discriminative analysis prior to descriptive analysis and consumer tests in terms of time and cost efficient work.

However, the third study shows how a consumer sensory test can help to find standard parameters for processing. The JAR scale showed that the hardness of one chocolate was indicated as just right for a large amount of consumer. In new product development, the hardness of this specific chocolate can be set as a reference to obtain the hedonic optimum for the consumer. This relation between sensory data and possible process parameters are illustrated in chapter 6.

Finally but definitely as important, is how the combination of instrumental and sensory analyses can identify positive or negative drivers of consumer acceptance. The third study is an example of this type of studies. Although it focused on texture, the results gave additional information on appearance, aroma and flavour and how important these attributes also are in the final acceptance. The results from the trained panel and the consumer panel are therefore complementary. This is in contrast to older sensory studies in which most researchers opted to work with a trained panel and to the new sensory studies in which mostly consumers are used (Jaeger et al., 2015, Rothman, 2007, Ares et al., 2015, Ares et al., 2014). Recently sensory scientists are developing consumer tests that capture more information than only acceptance or preference. A few examples are the just-about-right-scale, the check-all-that-applies or rate-all-that-applies method. These methods provide more insights on the consumer perception of the different sensory characteristics of food products. Although the results of these tests remain rather subjective whereas the trained panel delivers objective data, more and more studies are conducted in which these adjusted consumer tests are used for financial reasons and to get faster results (Meiselman, 2013).

As this chapter clearly shows how sensory analysis can provide information on process parameters, it can be inserted in the development stage of the Stage-Gate® process. This would require the use of a trained panel to perform the objective evaluations of the trial products. The use of this trained panel could significantly reduce the trial and error cycle to finetune the product. For SMEs, this will probably not be a realistic option. They could however use the new developed methods such as JAR-scale in the testing stage to find out what they can still change to the developed product. Some sensory characteristics can be used as criteria at the gate before entering the launch stage. However, this will never be an objective measurements but a rather subjective measurement of the sensory characteristics which limits the conclusions that can be made.

Part 2

Influence of emotions on consumer behaviour

CHOCOLATE COMES FROM COCOA
WHICH COMES OUT OF A TREE.
THAT MAKES IT A PLANT.
THEREFORE, CHOCOLATE COUNTS
AS A SALAD. the end.



Chapter 4

Do anticipated emotions influence behavioural intention and behaviour to consume filled chocolates: A cross-cultural study

Adapted from:

Gellynck, X., De Pelsmaeker, S., Delbaere, C., De Clercq, N., Hegyi, A., Küti, T., Depypere, F., Dewettinck, K. Influence of anticipated emotions on behavioural intention and behaviour to consume filled chocolates: a cross-cultural study. *Submitted in British Food Journal*

Abstract

This study proposes and tests an adapted version of Ajzens' Theory of Planned Behaviour (TPB) to explain the consumption of chocolate. Given that anticipated emotions are key factors of intention to consume food products, TPB is extended with the construct anticipated emotions. The aim is to examine the influence of anticipated emotions on behavioural intention and actual behaviour. This paper also gives an indication on the differences in consumer behaviour between two populations.

A total of 859 consumers in Belgium and Hungary completed the TPB questionnaire. The results of the regression analyses indicate that including anticipated emotions increases the predicted variance and helps explaining consumer behaviour towards chocolate. Moreover, anticipated emotions have a positive effect on the intention to eat and the actual behaviour of consumers.

Next, the study indicates that Belgian and Hungarian consumers are influenced by different beliefs in their behaviour. While the Belgian consumers were more influenced by their beliefs on control and emotions, the Hungarian consumers were driven by family and friends' opinion and some behavioural beliefs as well. Therefore, the current results suggest that this extended TPB may be a useful framework to predict the consumer behaviour toward emotive food products.

4.1. Introduction

Chocolate and filled chocolate are known for the arousal of sensory pleasure due to the specific melting behaviour, aroma and taste (Januszevska and Viaene, 2002, Mela, 2000, Parker et al., 2006). Several authors indicate that the popularity of chocolate is closely related to the emotions it evokes with the consumer (Macht and Dettmer, 2006, Parker et al., 2006). Given that it is the most frequently craved food (Frijters, 1993), chocolate has been defined as a comfort food (Wansink et al., 2003, Anonymous, 1975). Next to positive emotions, chocolate can also be related to negative emotions, particularly guilt (Macht and Dettmer, 2006). Macht and Dettmer (2006) found that in everyday life emotions of joy and guilt are present after eating a chocolate bar. Joy was related to sensory pleasure whereas guilt appeared to be induced by negative thoughts associated with eating chocolate. These studies indicate that whenever the behaviour of consumers towards eating chocolate is studied, these emotions need to be taken into account. In the past several years, a number of new methods have been developed to measure emotions associated with products (King et al., 2010, Porcherot et al., 2010, Thomson et al., 2010, Desmet et al., 2000). These previous studies focused on determining the differences in emotions elicited by different products thus during or after consumption.

Since the chocolate market is growing and evolving (Monotti, 2008) it is necessary to reveal what the drivers for consumption are in a cross-country setting. Many models, which take different, often interrelated factors into account, have been proposed to explain consumer behaviour towards chocolate and filled chocolates. The orientation to chocolate questionnaire (approach, avoidance and guilt) (Cartwright and Stritzke, 2008, Cartwright et al., 2007, Durkin et al., 2012), the attitude to chocolate questionnaire (ACQ) (craving, guilt and functional) (Benton et al., 1998, Müller et al., 2008) and the theory of planned behaviour (TPB) (Januszevska and Viaene, 2001a) have been used to explain the variance in chocolate consumption patterns. Other researchers used the craving questions from the ACQ (Osman and Sobal, 2006) to explain the emotions related to chocolate consumption.

These studies all conclude that emotions are important triggers for the consumer behaviour towards chocolate eating.

Moreover, previous literature indicates that past behaviour (De Canniere et al., 2009) or past experience (Verbeke and Vackier, 2005) influence the current behaviour. Similarly, perceived emotions from past behaviour will also affect the expected or anticipated emotions that drive current behaviour. This study focusses on anticipated emotions (AE) which are expectations or emotional beliefs before consumption (Bagozzi and Pieters, 1998, Lundahl, 2012), which could influence a behaviour. These AE can be included in the TPB to explain the behavioural intention and behaviour of consumers towards eating filled chocolates. Chapter 5 focuses on the emotions elicited by chocolate consumption.

Although there are many applications, in recent years, the use of TPB in consumer research has been strongly criticised, because it is based on a rational utilitarian model of consumer choice that does not account for unconscious and non-rational processes (Köster, 2009, Köster and Mojet, 2007). Conner and Armitage (1998) indicated that intentions do not always lead to successful prediction of the behaviour. The former is believed to be primarily a motivational process, while the latter is primarily a volitional process. The authors stated that an important shortcoming of TPB is its exclusion of affective processes, which are crucial for the intentional process (Van der Pligt et al., 1997). Such anticipated affective processes might be significant determinants of attitudes and intention to perform or not perform a behaviour (Van der Pligt and De Vries, 1998), especially in situations where the consequences of the behaviour are unpleasant or believed to be negative. An example is that when an individual anticipates experiencing a feeling of regret after performing behaviour, he or she will be unlikely to perform the behaviour. Simonson (1992) confirmed the effects of anticipated affective reactions on consumer behaviour and suggested that further research to understand this effect is necessary. Moreover, Richard et al. (1996) state that besides attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC), anticipated affective reactions are significant predictors of behaviour expectancy for eating junk foods, using soft drugs and alcohol use. This type of behaviour can be perceived to be related to the consumption of chocolate as addiction (Hetherington, 2001).

Several studies attempted to include anticipated affective reactions in the TPB to explain a specific behaviour, although there is a variation in the way this is operationalized. Van der Pligt (1997) argued that it is interesting to work with more specific affective reactions (e.g. regret, guilt, envy) rather than with simple positive/negative affective reactions. Richard et al. (1996) used a measure similar to the one to measure attitudes, while Parker et al. (1992) used a measure similar to one that taps into behavioural beliefs and evaluations. Richard et al. (1998) discussed the advantages and disadvantages of measuring these affective influences either as beliefs leading to attitude or as a direct predictor of intentions. Mohiyeddini et al. (2009) argued that when the affective beliefs are presented in the TPB as a precursor for attitude, this seems to be so closely related to cognitive and behavioural aspects that its impact on attitude is hardly measurable (Dillon and Kumar, 1985). Another study used anticipated emotions as a precursor for intentions stating that it transforms the motivational content to act given by ATT, SN and PBC into intention (Perugini and Bagozzi, 2001, Carrus, 2008). Therefore, anticipated emotions are added as a separate component and predictor to intention and behaviour of the TPB in this study.

This study was conducted in two countries. The present study focuses on consumers from Western and Central Europe namely Belgium and Hungary. The rationale for this choice is based on the cultural differences between these countries and the position of chocolate on both markets and as explained in Chapter 1 these countries were included in the ProPraline study. Moreover, Afoakwa (2010) stated that per capita consumption levels tend to be highest in the more northerly European countries or those with a strong chocolate heritage.

Belgium is a country renowned for its chocolate and chocolate has a long tradition in this country (Garrone et al., 2015). The label "Belgian Chocolate" is often used to promote chocolate, as consumers see it as a mark of quality. As one of the highest chocolate producing countries in Europe and a large consumption per capita (7,30kg/capita in 2011) (Caobisco, 2013), it is possible that factors, beside guilt and craving, are important factors for the chocolate purchase and consumption. This high consumption also indicates that eating chocolate has become a habit for Belgian people. This might lead to a short decision process in which little time is invested.

Hungarian chocolate consumers are loyal to good quality offerings and they are reluctant to purchase cheaper, lower-quality products. This can be concluded from the stagnated retail volume sales after the public health tax in 2011 and rising prices on the Hungarian market (Euromonitor, 2014). The chocolate consumption of Hungarian consumers (2,89kg/capita in 2011) is lower than the consumption of Belgian consumers (Caobisco, 2013). This suggests that consumption of chocolate is not as frequent in Hungary as in Belgium and thus believed not to be a habit for the Hungarian consumers. Moreover, it is believed to be a luxury product. Consequently, the decision process will be more extensive than for Belgian consumers.

The primary objective of this research is to study consumer behaviour towards filled chocolate consumption in Belgium and Hungary using the theory of planned behaviour (TPB) as a research framework. The second objective is to examine the influence of anticipated emotions on the behavioural intention and behaviour of chocolate consumers. Finally, the third objective is to determine if there are cultural differences between the Belgian and Hungarian consumers. In the following sections, the research framework, research hypotheses and research method are described. Our work contributes to the growing literature on emotions as it does not focus on emotions elicited during or after consumption, but explores if the anticipated emotions also play a significant role in behaviour. It is not the aim of this study to criticise the TPB but to study if the explained variance of the model is higher when anticipated emotions are integrated in the model when studying the consumer behaviour towards filled chocolate.

4.2. Research hypotheses

4.2.1. Behavioural intention

Januszezka (2001a) studied the consumer behaviour towards eating chocolate of Belgian and Polish consumers through the Theory of Planned Behaviour. The results indicated that for the Belgian consumers only attitude was important as predictor for the behavioural intention and the behaviour of the consumers. For the Polish consumers, both attitude and perceived behaviour control were defining the behavioural intention. However, again only behavioural intention was explaining the behaviour of the consumers without additional explained variance from PBC. Therefore, the first aim is to study if the TPB can be applied in the prediction of the behavioural intention and behaviour in eating filled chocolates. Since no previous comparison consumer research related to filled chocolate consumption in Belgium and Hungary, a general hypothesis with respect to determinants of behavioural intention is formulated:

- **H1: Attitude towards eating filled chocolate, subjective norm and perceived behavioural control have a positive impact on behavioural intention to eat filled chocolates ($\beta_{ATT}, \beta_{SN}, \beta_{PBC} > 0$)**

4.2.2. Impact of anticipated emotions

Perugini (2001) stated that inserting an independent variable to the existing theory in order to explain more of the variance, can be seen as theory broadening. Accordingly, the impact of this construct in comparison to the traditional constructs (ATT, SN and PBC) of the model is analysed. The study is applied to the consumption behaviour of an emotive food product, namely filled chocolate, for Belgian and Hungarian consumers. Dubé, LeBel & Lu (2005) state that chocolate, a high-calorie sweet food product, is a typical comfort food, that affects negative emotions and to a lesser extent positive emotions, has a negative affect under stressful conditions and is often the object of cravings. Since filled chocolate is defined as a confectionary chocolate product (Ali et al., 2001), it is also known as a comfort food. Consequently, the present research aims to find out if adding the construct of anticipated emotions will increase the predictive variability of the model. Moreover, the study wants to reveal if the factor of anticipated emotions does not only act as a construct in the prediction of behavioural intention but also in the prediction of behaviour. Since literature on extending TPB with the construct anticipated emotions does not exist, the following hypotheses are presented:

- **H2: The R^2 of the model to predict behavioural intention will increase after extending the model with the construct anticipated emotions.**
- **H3: Intention to eat filled chocolates combined with anticipated emotions has higher R^2 in explaining behaviour than intention to eat filled chocolates combined with perceived behaviour control.**

4.2.3. Cross-cultural differences

Filled chocolate is an exclusive and niche product being part of the European chocolate industry which is a high added value export product (Depypere et al., 2009b). As it is a rather expensive product, it is likely that the economic situation of the consumers play a role in their behaviour towards the product. As this research was conducted in the frame of the FP7 project ProPraline in which Ghent University (Belgium) and Campden BRI Hungary were partners, Belgium and Hungary were chosen as representative countries for respectively Western and Eastern Europe. The GDP (gross domestic product), a measurement for the economic activity, of these countries indicate that the economic situation is different in Belgium and Hungary. Additionally, several authors state that there are differences in consumer behaviour between European countries (Kuhne et al., 2010, Van Trijp and Steenkamp, 1998, Urban and Hauser, 1993). Petrovici, Ritson & Ness (2005) proved that consumers in Western European countries have a different profile than consumers in Eastern Europe. Finally, filled chocolate has a different market profile in Belgium, where it is a common product, than in Hungary, where it has a more exclusive character. This cross-country study aims to identify the distinctive consumer behaviour of Belgian and Hungarian consumers. Consequently, the final hypothesis is formulated:

- **H4: The consumer behaviour is different for Belgian and Hungarian consumers.**

Figure 4. 1 shows the research framework and how these hypotheses relate to the framework.

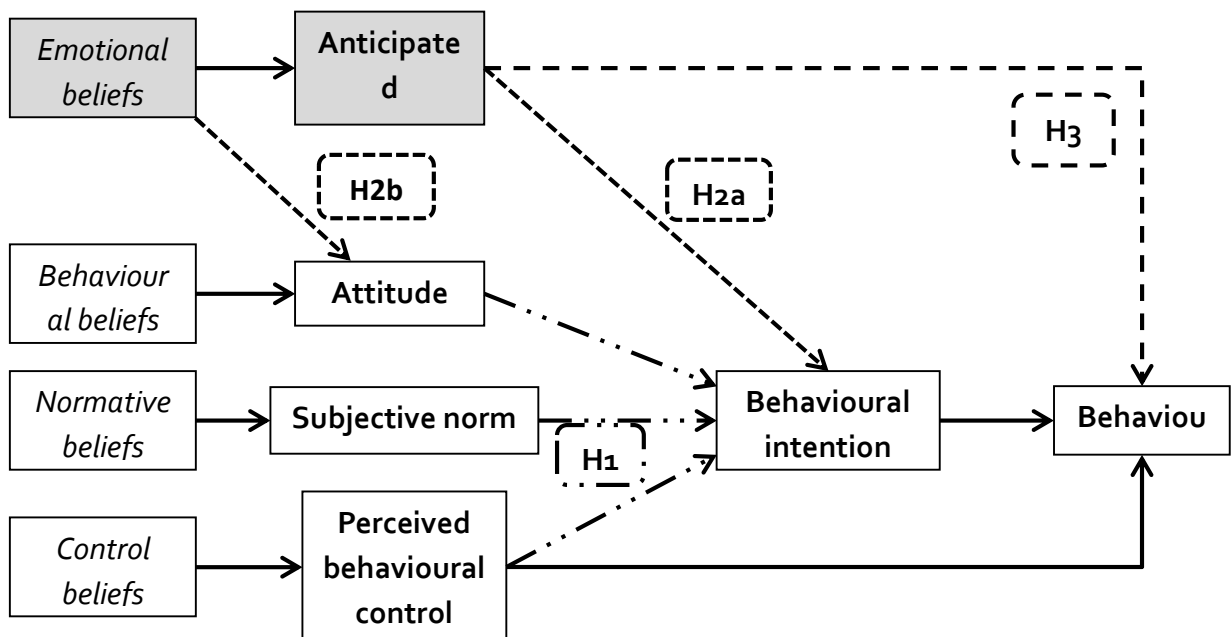


Figure 4. 1: Research framework: the theory of planned behaviour with application of anticipated emotions; dotted lines represent the hypotheses. The extended construct and beliefs have a grey background

4.3. *Materials and method*

4.3.1. Questionnaire design

4.3.1.1. *Set-up and pre-test*

The questionnaire is constructed in accordance with the guidelines defined by Ajzen (Ajzen, 2010, Ajzen, 1991) who indicates that there is no standard questionnaire for TPB but a standard construction procedure. Ajzen (1991) states that the questionnaire can only be built after conducting an elicitation study in which the salient beliefs for the behaviour that is being studied are gathered. These salient beliefs are then used to construct the questionnaire. The target behaviour in this study is defined here as 'eating filled chocolate' and the target research population is defined as both Belgian and Hungarian chocolate consumers.

A small group of individuals who are part of the research population in both countries namely frequent chocolate consumers, is used to conduct the elicitation study to reveal the salient beliefs for ATT, SN, PBC and anticipated emotions. These respondents were randomly selected at Ghent University (Belgium) and Campden BRI (Hungary). Each respondent completed the elicitation test by filling in a short questionnaire individually. This elicitation test contained only open-ended questions. The test was developed in English and back-translated to Hungarian and Dutch (Brislin, 1970). The following questions were asked: "Why would you consider to eat or not eat filled chocolates (advantages and disadvantages)?"; "Are there any individuals or groups who would approve or disapprove if you eat filled chocolates?"; "What factors or circumstances would enable or prevent you to eat filled chocolates?"; "Which positive and negative emotions do you associate with eating filled chocolates?" (Ajzen, 2010). A content analysis of the responses to the above questions results in a list of salient beliefs for the major constructs in the questionnaire (Table 4. 1).

Table 4. 1: Salient beliefs for attitude, subjective norm, perceived behavioural control and anticipated emotions, derived from elicitation study

Behavioural beliefs	Normative beliefs	Perceived ease/difficulty of performing behaviour beliefs	Emotional beliefs
Gaining weight	Family	Have problems with weight	I will feel happy
Becoming unhealthy	Friends	When visiting	I will feel guilty
Receive an overload in sugar/calories	Partner	Having trouble with money	I will enjoy it (e.g. nice taste) When I'm worried (comfort)

The number of beliefs that are taken into account, is kept limited as the selected beliefs already lead to a long questionnaire. The beliefs were selected as the three or four most given answers, based on a cut-off value, to the elicitation study. Moreover, when defining the emotional beliefs, no more than four were selected as not to dominate the questionnaire with questions constructed on the emotional beliefs.

Before conducting the final questionnaire, a pre-test with 20 individuals in both countries is performed. This pre-test indicated that the wording of the questions was clear for the consumers.

4.3.1.2. *Questionnaire*

The present questionnaire consisted of two main parts. The first part dealt with the socio-demographics of the respondents. The second part consisted of the questions to construct the model of Theory of Planned Behaviour. This second part contained questions on behaviour, behavioural intention, attitude, subjective norm, perceived behavioural control and anticipated emotions. For the behaviour and behavioural intention, only direct measurements were included. For the attitude, subjective norm, perceived behavioural control and anticipated emotions both direct and indirect measurements were constructed as recommended by Ajzen (1991, 2010). Similar as for the elicitation study, the questionnaire was developed in English and back-translated to Hungarian and Dutch by the researchers.

Socio-demographics are assessed through self-reporting and consisted of gender, age, height, weight, education, number of people and children in the households, residence (city or countryside), income and nationality. Additionally, the respondents are asked if they watched their weight.

Behavioural Intention (BI) is assessed by three items recommended by Ajzen (2010). Two items are given as: "In the next two weeks,...(1) I intend to have filled chocolates in my household, and (2) I plan to eat filled chocolates on a regular basis" rated on a scale from 1 (strongly disagree) to 7 (strongly agree). The last item is an open ended question: "How many filled chocolates do you expect to eat in the next two weeks in pieces?" Given the different scaling formats, the items were converted to z-scores prior to aggregation.

Consumption behaviour (B) is measured by two items. The statement for the first item was "Within the past two weeks, I ate filled chocolates ..." with scale from 1 (never) to 7 (very frequently). The second item is presented in an open ended question: "The total amount of filled chocolates I ate in the last two weeks (in pieces of filled chocolates)..." Given the different scaling formats, the items were converted to z-scores prior to aggregation.

Then the following constructs are measured through *indirect measurements*.

Attitude is based on salient behavioural beliefs (BB_i) and the significance of the outcome evaluations (OE_i). Behavioural beliefs refer to somebody's perceived probability that something will happen when they behave in a certain way. The outcome evaluations are defined as the assessment of possible consequences of this particular behaviour (Ajzen and Fishbein, 1980). The attitude is estimated by aggregating the multiplication of behavioural beliefs and the evaluation of the outcome ($\sum BB_i OE_i$) (Ajzen and Fishbein, 1980, Ajzen, 1991, Ajzen, 2010).

Subjective norm is a function of normative beliefs (NB_j) and motivation to comply (MC_j). Normative beliefs are the perceived behavioural expectations of one's important referents

(e.g., family, relatives, friends, or co-workers) or in other words it is related to whether someone else would approve or disapprove the behaviour (Han et al., 2010). The motivation to comply involves a person's anticipated belief to live up to the opinions of his/her salient referents with regard to behaviour. A similar equation as for attitude is used to determine the subjective norm ($\sum NB_j MC_j$) (Ajzen and Fishbein, 1980, Ajzen, 1991, Ajzen, 2010).

Perceived behavioural control is based on the function of control beliefs (CB_k) and perceived power (PP_k). Control beliefs are the perceived presence (or absence) of resources and opportunities that facilitate (or obstruct) performance of a particular behaviour. Perceived power of each control factor refers to the personal opinion of the importance of these resources and opportunities. Again, the multiplication of each control belief to a corresponding perceived power is used to calculate the value for PBC ($\sum CB_k PP_k$) (Ajzen and Fishbein, 1980, Ajzen, 1991, Ajzen, 2010).

In accordance to the three previous factors, the construct of *anticipated emotions* is composed as a function of emotional beliefs (EB_i) and emotional power (EP_i). Here, the emotional beliefs represent the anticipated emotions present in the decision to eat filled chocolates. The emotional power refers to the influence that these anticipated emotions can have on a person when performing or after this behaviour. The products of emotional belief and emotional power are summed, similar to the other constructs, to calculate a value for desire ($\sum EB_i EP_i$).

The beliefs given in Table 4. 1 are all measured on a 7-point scale from 1 (extremely unlikely) to 7 (extremely likely). All the statements related to the beliefs were preceded by the question: "Indicate for the following statements, how likely you think they are".

The measurement of the outcomes was done by reformulating the questions as suggested by Ajzen (2010). These outcomes for ATT were measured on a 7-point scale from 1 (extremely undesirable) to 7 (extremely desirable) and preceded by the statement "Please indicate for the following statements how desirable they are". The outcomes for SN were preceded by the statement "Please indicate for the following statements how much you care about the opinion of these people regarding the consumption of pralines". Finally, the outcomes for PBC and outcomes for anticipated emotions are analysed on a scale from 1 (less likely) to 7 (more likely) with the statement "Please indicate for the following statements how likely they are".

Further, Ajzen (1991) indicated that next to indirect measurement, direct measurements also need to be part of the questionnaire. There must be a correlation between these direct measurements and indirect measurements in order to use the indirect ones for further analysis. The *direct measures* of the theory's major constructs are formulated. Direct measuring of *attitude* was performed with a seven-point bipolar adjective scale including four bipolar adjectives: good vs. bad, pleasant vs. unpleasant, healthy vs. unhealthy and gives instant energy vs. slows down. The direct measure of *subjective norm* consisted of three statements on a seven-point Likert scale: "People who are important to me think I should eat

filled chocolates”; “It is expected from me that I eat filled chocolates” and “People who influence my decisions would approve that I eat filled chocolates”. Direct measurement of the *perceived behavioural control* was done with five items as suggested by Ajzen (1991). Two items are seven-point bipolar adjective scales for “In my opinion, eating filled chocolates is...” namely easy vs. difficult and financially possible vs. financially impossible. The other three items were rated on a seven-point Likert scale: “I am confident that I can stop eating filled chocolates when I want to”; “The decision to eat filled chocolates is up to me” and “I have complete control over the amount of chocolate I eat”. The means of the direct questions on ATT, SN and PC are calculated for further analysis. As *anticipated emotions* is considered as a major construction factor for the model, a direct measure for this factor is constructed similar to the other factors. A seven-point Likert scale is used: “I have a strong desire to eat filled chocolates”; “My emotions are strongly related to the consumption of filled chocolates”. The number of questions is limited so that none of the factors would dominate the questionnaire.

4.3.2. Data collection

Before conducting the final questionnaire, a pre-test with 20 individuals was performed in both countries. A total of 859 responses were received of which 459 in Belgium and 400 in Hungary. All data were collected within a four week time period. Cross-sectional data were collected through a web-based survey in Belgium and Hungary. The respondents completed a self-administered questionnaire on computers in the lab or online. In this study a convenience sampling procedure was used. It is important to note that the non-probability sampling and respondent selection procedures do not yield a statistically representative sample. Therefore, it is not allowed to generalize the results to the overall population. Nevertheless, the sample covers a wide range of consumers in terms of socio-demographics. In Belgium the respondents were recruited around Ghent whereas the participants in Hungary were recruited in the capital city Budapest. As incentive, coupons from a bookstore were distributed via lottery.

In the opening instructions of the survey, a detailed description of the questionnaire was provided. Moreover, it was explained that the survey was part of a European project on the quality of filled chocolate. Since our objective is to explain the behaviour of chocolate consumers, rather than exploring the decision whether or not to eat filled chocolate, all the respondents met the criteria of being a filled chocolate consumer. Further, the respondents were not allowed to have participated in a study on filled chocolate in the last six months to avoid biased results.

Table 4. 2 shows that there were more female respondents than male respondents in both countries. In Belgium, younger people participated in the study as a part of the respondents were recruited at the Ghent University. The Belgians had a lower BMI than the Hungarian people. In Belgium, more respondents suffered from underweight whereas overweight and obesity occurred more with the Hungarian participants. In both countries, 40% of the respondents indicated that they do not watch their weight. As the Hungarian participants

were recruited in Budapest, they are almost all inhabitants of the capital city. In Belgium this is more divided over people from the cities and the countryside.

4.3.3. Data analysis

Data was analysed using SPSS Statistics 19. Preliminary data analyses were done to delete all the answers that included a missing variable. This study focuses on the difference in consumer behaviour of Belgian and Hungarian consumers. The TPB means and standard deviations for both nationalities were calculated in addition to the Pearson correlation coefficients between the direct and indirect measurements of the major constructs of the model. As the traditional TPB model is extended with the construct anticipated emotions, the correlation for this construct was measured as well. Regression analysis (Enter-method) was used to determine the relationships determined in Hypothesis 1 – 3. In the results, the R^2 presents the explained variance off the overall model and the beta-coefficients are the coefficients in the linear regression equation. As this is most common, only linear models are used in the analysis.

Table 4. 2: Socio-demographic characteristics of the total sample and both countries separately (in % of respondents)

	Belgian (N=459)	Hungarian (N=400)	Total (N=859)		Belgian (N=459)	Hungarian (N=400)	Total (N=859)
1. Gender				3. BMI			
Female	60.1	61.5	60.8	<18.5	5.9	2.8	4.4
Male	39.9	38.5	39.2	18.5-24.9	65.1	56.3	61.0
				25-29.9	22.7	29.0	25.6
2. Age				>30	6.3	12.0	9.0
<18	1.1	0.8	0.9				
18-25	31.8	20.0	26.3	4. Weight-control			
26-30	22.0	17.3	19.8	No	40.5	41.0	40.7
31-40	22.7	28.5	25.4	Yes	59.5	59.0	59.3
41-50	13.5	16.0	14.7				
51-60	6.8	11.5	9.0	5. Residence			
61-70	2.0	5.8	3.7	City	37.5	98.8	66.0
>70	0.2	0.3	0.2	Countryside	62.5	1.2	34.0

4.4. Results

First, the correlations between direct and indirect measures are calculated to ensure that data analysis can be conducted with the mean scores of the indirect measurements. Direct measures are more general questions related to behaviour whereas the indirect measurements are based on the salient beliefs collected by qualitative research. These direct measurements serve as control questions to indicate if the indirect questions are a good indication for ATT, SN, PBC and AE.

The correlations between the direct and indirect (as used in the final model) measures for ATT, SN, PBC and AE were all significant for the Belgian consumers: 0.116 ($p=0.013$), 0.434 ($p<0.001$), 0.139 ($p=0.003$) and 0.580 ($p<0.001$). Although the correlations are rather low, the significance of the correlations indicate that the statements based on the salient beliefs (indirect measures) are related to the direct and more general ATT, SN, PBC and AE and therefore valid for measuring the different constructs.

The correlations for the Hungarian consumers are significant for SN, PBC and AE: 0.476 ($p<0.001$), 0.287 ($p<0.001$) and 0.551 ($p<0.001$). However, the direct and indirect measurements for ATT are not significantly correlated: 0.013 ($p=0.790$). Since we want to compare the behaviour between Belgian and Hungarian consumers, the questionnaire was not adjusted. For all further analyses, the indirect measurements of the questionnaire are used. Table 4. 3 presents the mean values for the direct measurements of the constructs. These will be used in the discussion of the results.

Table 4. 3: Mean and standard deviation of the major constructs based on direct measurements in the Theory of Planned Behaviour

Construct	Belgian	Hungarian
Behaviour (B)	2.4±1.7	3.8±2.1
Behavioural intention (BI)	2.8±1.6	4.0±2.0
Attitude (ATT)	4.4±0.7	5.1±1.0
Subjective norm (SN)	4.1±1.4	3.4±1.2
Perceived behavioural control (PBC)	5.9±0.9	5.7±1.0
Anticipated emotions (AE)	3.0±1.5	3.6±1.8

The mean scores for the different items to construct BI and B and the overall mean scores for these two items are given in Table 4. 4. The results indicate that Hungarian consumers indicate that they have a significant higher BI and B towards eating filled chocolates than Belgian consumers. This result is presented in the mean scores for all individual items as well as for the overall mean scores for BI and B.

Moreover, the significant differences on socio-demographic characteristics within the two populations of the mean scores for BI and B is analysed.

For the Belgian consumers, the results indicate that there is no significant difference between male and female respondents on BI or B. Similar results are found for weight-control and residence. However, for age a significant differences is found for both BI and B. The results indicate that respondents in the age-category 18-30 have the lowest intention to eat filled chocolates than the older consumers. Correspondingly, in this age category, respondents indicate to have the lowest actual behaviour to eat filled chocolate. When looking at BMI, consumers with a BMI between 25-29.9 indicate to have a higher intention to eat filled chocolate than others. This is not extrapolated in differences for B.

Table 4. 4: Mean values and significant differences for the behavioural intention and behaviour towards eating filled chocolates

	Mean	Belgium	Hungary	p-value
Behavioural intention	3.4±1.93	2.80±1.6	4.0±2.0	<0.001
Amount expect to eat	3.7±2.5	3.1±2.2	4.3±2.6	<0.001
Intend to have filled chocolate	3.4±2.1	2.8±1.8	4.1±2.1	<0.001
Plan to eat filled chocolate on regular basis	3.0±1.9	2.5±1.6	3.6±2.0	<0.001
Behaviour	3.1±2.0	2.4±1.7	3.8±2.1	<0.001
Amount ate in the last two weeks	3.7±2.6	2.9±2.3	4.5±2.6	<0.001
Frequency of eating filled chocolate in last two weeks	2.4±1.6	1.9±1.3	3.0±1.7	<0.001

Among the Hungarian consumers, there are no significant differences found for age or residence. Female respondents indicate to have a higher BI and B towards eating filled chocolate. For weight-control, the analysis shows that people who watch their weight have a higher BI and B to eat filled chocolates. Significant differences are also found for respondents with different BMI scores related to B. Contrary to the results of the Belgian consumers, Hungarian respondents with a BMI score of 25-29.9 indicate to eat less chocolate than other categories whereas the respondents with a BMI score of > 30 indicate to eat filled chocolates most frequently.

4.4.1. Determinants of behavioural intention (Hypothesis 1)

A linear regression is conducted to explain the BI and define which constructs are relevant. Three models are calculated. The first model follows the traditional TPB with the constructs ATT, SN and PBC (Model 1). The second model includes next to these three traditional factors, the anticipated emotions to explain the BI (Model 2). The third and final model shows an ATT' that comprises both the behavioural beliefs and the emotional beliefs (Model 3).

4.4.1.1. *Belgian consumers*

With a Cronbach's alpha of 0.838, the construct of behavioural intention has a high internal reliability and thus the calculated value can serve for BI. The first analysis in Table 4. 5 (Model 1) examines the influence of the three traditional determinants (ATT, SN and PBC) of intention. This yielded a low percentage of explained variance of 17.4%. The results indicate that SN has no impact on the intention to eat filled chocolate as the beta coefficient has a significant level higher than 0.05. For the Belgian consumers, SN did not contribute to the

explanation of the BI. This suggests that the intention to eat filled chocolates is a personal decision. Therefore, Belgian consumers indicated that family, friends or other people do not have an influence on their intention to eat filled chocolates. However, the result may also reflect insufficiency of the SN measure or the unconscious nature of the social influence. Since this is self-reported data, it is necessary to be careful when drawing conclusions from the data.

ATT is the best predictor of behavioural intention ($\beta=0.399$; $r=0.377$) (Table 4. 5). Next to the high positive regression and correlation coefficient, the direct mean score of 4.39 (Table 4. 3) reflects that the three beliefs measuring ATT also are positively influencing the intention to eat filled chocolates. Further, the effect of PBC was lower and negative ($\beta = -0.173$; $r = -0.092$). The mean direct score of 5.90 for the four variables measuring the PBC indicates that the respondents believe that they have control on their behaviour.

Table 4. 5: Construct parameters (Beta coefficient, correlation and R^2) for the prediction of behavioural intention in TPB with and without the factor anticipated emotions

	Independent variable	Belgium			Hungary		
		Beta	Correlation	R^2	Beta	Correlation	R^2
<i>Model 1</i>	ATT	0.399***	0.377***	0.174	0.406***	0.407***	0.223
	SN	0.057	0.134**		0.123**	0.238***	
	PBC	-0.173***	-0.092*		-0.185***	-0.157***	
<i>Model 2</i>	ATT	0.325***	0.377***	0.247	0.244***	0.407***	0.444
	SN	0.004	0.134**		0.058	0.238***	
	PBC	-0.074	-0.092*		-0.070	-0.157**	
	AE	0.299***	0.391***		0.516***	0.620***	
<i>Model 3</i>	ATT'	0.197***	0.352***	0.198	0.103*	0.300***	0.247
	SN	0.001	0.082*		0.102*	0.287***	
	PBC	0.313***	0.411***		0.393***	0.474***	

NS – not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

The results for PBC suggest that a high feeling of control has a negative influence on the intention to eat filled chocolates. On the other hand, a low feeling of control would lead to a positive influence on intention to eat filled chocolates.

4.4.1.2. Hungarian consumers

The construct of behavioural intention has a high internal reliability (Cronbach's $\alpha=0.879$). Application of the TPB indicated that all three constructs (ATT, SN and PBC) are relevant in explaining the intention (Table 4. 5, Model 1). ATT is the most important predictor of intention to eat filled chocolates. The explained variance ($R^2=0.223$) of the model is higher than for the Belgian consumer. Similar as for Belgian consumers, the overall ATT of the Hungarian consumers is positive with a mean score of 5.05. SN has a positive influence on the intention whereas PBC has a negative influence. The peers of the Hungarian respondent thus might have an influence on behaviour intention which is not the case for Belgian consumers.

4.4.2. TPB and anticipated emotions (Hypothesis 2)

As presented in the research framework, the determinant of 'anticipated emotions' (AE) is included as a separate variable to predict the intention to eat filled chocolate (Table 4. 5, Model 2) (Figure 4. 1, H2a). The same constructs are used for behavioural intention as in 4.4.1.

4.4.2.1. Belgian consumers

For the Belgian consumers, incorporating AE yields a substantial increase in the explained variance to 24.7%, indicating that AE is a relevant factor in predicting the intention to consume filled chocolates (Table 4. 5, Model 2). From the traditional determinants of intention, only ATT remains significant, although the importance of ATT decreases. Both SN and PBC are not or no longer explaining the behavioural intention of the Belgian consumers.

Including AE as a construct, causes a decrease in the regression coefficient of ATT. Thus the idea rises that AE can be included in the construct ATT as affective belief (Figure 4. 1, H2b). Therefore, a simulation of the TPB model is conducted in which the ATT factor consists of both original behavioural beliefs and emotional beliefs (Table 4. 5, Model 3). The results indicate that the explained variance (0.198) is lower than when the model is constructed with AE as a separate independent variable.

4.4.2.2. Hungarian consumers

The addition of emotions into the model increased the predictive power to $R^2=0.444$ (Table 4. 5, Model 2). Anticipated emotion is the most important factor in predicting intention whereas the influence of ATT and SN is decreased. Moreover, the influence of SN and PBC are no longer significant. Similar to the data for the Belgian consumers, including AE in the model decreases the regression coefficient of ATT (Figure 4. 1, H2b). Therefore, a new ATT is constructed which includes behavioural and emotional beliefs (Table 4. 5, Model 3). The explained variance (0.247) is lower for this model than when AE is a separate independent variable.

4.4.3. Behaviour and anticipated emotions (Hypothesis 3)

Again linear regression was used to identify the predicting concepts and define the explained variance. Again three models are calculated. In the first model, the B is only predicted by BI. The second model includes PBC next to BI and in the third model B is explained by BI and AE.

4.4.3.1. Belgian consumers

The Cronbach's alpha of the construct behaviour (0.802) confirms a high internal reliability of this factor. The traditional TPB hypothesizes that, although the intention to perform a behaviour is present, the ability to do so can be absent (Ajzen, 2010, Ajzen, 1991). Model 1 indicated that behavioural intention explains 28.5% of the variance. The results of model 2 are shown in Table 4. 6 and indicate that PBC is not significantly explaining the behaviour for the Belgian consumers. As filled chocolate is an emotive product, it can be hypothesized that

emotions play an important role in predicting consumer behaviour (Figure 4. 1, H₃). The findings of model 3 (Table 4. 6) confirm hypothesis 3 for the Belgian consumers since both behavioural intention and anticipated emotions have a significant positive effect on filled chocolate consumption, explaining 30.1% of the variance. The high positive correlation between intention to eat filled chocolate ($r=0.534$; $p<0.001$) already reveals that when consumers have an intention to eat, they most of the time perform the behaviour of eating filled chocolate. Moreover, besides the effect of intention, anticipated emotions has an additional positive effect on the consumption of filled chocolate.

4.4.3.2. Hungarian consumers

With a Cronbach's alpha of 0.866, the construct behaviour for Hungarian consumers has a high internal reliability. Model 1 shows that BI explains 62.7% of the variance in behaviour. Model 2 indicates that both intention to eat filled chocolate and perceived behavioural control have significant impact on the consumption of filled chocolate ($R^2=0.633$) (Table 4. 6). However, although behaviour intention is highly positively correlated ($r=0.792$; $p<0.001$), perceived behaviour control is negatively correlated ($r = -0.196$; $p<0.001$) with behaviour. The latter indicates that individuals who believe to have control will unlikely eat filled chocolate. A multiple regression predicting behaviour with the constructs behavioural intention and anticipated emotions has a slightly higher explained variance ($R^2=0.647$) (Model 3). The positive significant correlation between behaviour and anticipated emotions indicate that consumers who believe to experience the anticipated emotions after consumption will likely perform the actual behaviour. Therefore, hypothesis 3 is confirmed for the Hungarian consumers as well.

Table 4. 6: Construct parameters (Beta coefficient, correlation and R^2) for the prediction of behaviour in TPB

	Independent variable	Belgium			Hungary		
		Beta	Correlation	R^2	Beta	Correlation	R^2
Model 1	BI	0.534***	0.534***	0.285	0.792***	0.792***	0.627
Model 2	BI	0.530***	0.534***	0.287	0.781***	0.792***	0.633
	PBC	-0.041	-0.090*		-0.074*	-0.196***	
Model 3	BI	0.480***	0.534***	0.301	0.681***	0.792***	0.647
	AE	0.138***	0.326***		0.180***	0.602***	

NS – not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

4.4.4. Consumer differences between Belgian and Hungarian consumers (Hypothesis 4)

Table 4. 5 and Table 4. 6 show correlations between all the TPB variables and anticipated emotions for both nationalities. For the Belgian as well as for Hungarian consumers, the strongest correlation was between behaviour and behavioural intention (Belgians: 0.534^{***} , $p<0.001$; Hungarians: 0.792^{***} , $p<0.001$). Ajzen & Fishbein (1980) claim that the model is only applicable when the correlation between these two variables is high. Frequently, the intended behaviour is obstructed by external events before it can be converted to actual

behaviour. Therefore, it is recommended to focus first on the intentional behaviour rather than on the behaviour itself. Hence, the major constructs that explain behavioural intention (ATT, SN and PBC) and the construct anticipated emotions were assessed to determine whether they significantly influence behavioural intention. When calculating the traditional TPB, the results indicate that for Hungarian consumers, subjective norm is significantly explaining behavioural intention whereas for the Belgian consumers this is not an important factor. When the construct anticipated emotions is included, only attitude and anticipated emotions significantly explain behavioural intention.

Table 4.7 highlights differences in salient beliefs concerning consumption of filled chocolates between the two groups. The table only shows the significant constructs for the consumers explaining BI and B. The Belgian consumers' BI is influenced by two behavioural beliefs namely '*gaining weight*' and '*level of sugar/calories*' whereas the Hungarian respondents only care about '*gaining weight*'. It must be highlighted that the results of the indirect measurements of the behavioural beliefs were reversed. Therefore, this indicates that a when consumers believe that they will not gain weight or when they believe that the filled chocolate does not have a high level of sugar/calories, it is more likely that they might eat that product. In the traditional model, PBC is significant for both groups of consumers, all control beliefs are correlated to BI. For the Hungarian consumers, all normative beliefs are also correlated to the BI to consume filled chocolates.

When the model is extended with the construct AE, both groups associate the intention of consuming filled chocolates with a feeling of happiness and indicate that they eat filled chocolates when they worry about something. The Belgian consumers are interested in the enjoyment due to taste whereas the Hungarian consumers associate the intention to eat filled chocolates with a guilty feeling.

The actual behaviour of the both respondent groups is related to AE. The significant emotional beliefs that are explaining the behaviour for both nationalities are identical to those explaining intention to consume. Table 4. 7 shows that all included control beliefs are significant for the Hungarian consumers in the explaining of the behaviour.

The study indicates that Belgian and Hungarian people present a different behaviour for eating filled chocolate which confirms hypothesis 4.

Table 4. 7: Results from multiple regression analyses for both countries with behavioural intention and behaviour as dependent variables and salient belief as independent variables

Belief	Correlation to BI		Correlation to B	
	Belgian	Hungarian	Belgian	Hungarian
<i>Behavioural beliefs</i>				
Gaining weight	0.099*	0.209***	-	-
Becoming unhealthy	0.003 ^{NS}	0.072 ^{NS}	-	-
Receive an overload in sugar/calories	0.105*	0.010 ^{NS}	-	-
<i>Normative beliefs</i>				
Family	-	0.250***	-	-
Friends	-	0.272***	-	-
Partner	-	0.278***	-	-
<i>Control beliefs</i>				
Have problems with weight	0.100*	0.312***	-	0.323***
When visiting	0.259***	0.351***	-	0.381***
Having trouble with money	0.109*	0.303***	-	0.332***
<i>Emotional beliefs</i>				
Will feel happy	0.361***	0.169**	0.301***	0.188***
Will feel guilty	- 0.023 ^{NS}	0.118*	- 0.049 ^{NS}	0.153**
Will enjoy the nice taste	0.261***	0.018 ^{NS}	0.154**	0.005 ^{NS}
When I'm worried (comfort)	0.345***	0.432***	0.237***	0.431***

NS – not significant; * p < 0.05; ** p < 0.01; *** p < 0.001

4.5. Discussion

This is the first study that compares the fit of the TPB model with and without the construct of anticipated emotions. The results clearly indicate that anticipated emotions both help explaining the intention to consume and the actual behaviour of consumption for eating filled chocolates.

The present study focuses specifically on behaviour of eating filled chocolate. Contrary to consumption figures of chocolate and confectionary consumption, Hungarian consumers indicate to have a higher intention and actual behaviour to eat filled chocolates. Within the Belgian society, filled chocolates are products that have an old-fashioned status. This is confirmed by the significantly higher BI and B for older consumers. For Hungarian consumers, filled chocolates are related to higher status in society and therefore are consumed in every age category. Again females indicate to have a higher intention and actual behaviour to eat chocolate.

4.5.1. Determinants of behavioural intention

The first objective of this research was to study the predictive value of the traditional TPB in the context of consumption of filled chocolates in both Belgium and Hungary. Overall, the results of the low explained variance confirm the criticism on the traditional TPB that it might be unfitted for the unconscious processes (Köster, 2009, Köster and Mojet, 2007, Conner and Armitage, 1998). However, previous studies also noted values for explained variance of 30% and lower (Blanchard et al., 2009b, Armitage and Conner, 2001, De Bruijn, 2010).

After analysing the results and using the traditional TPB to explain BI, differences were found between Belgian and Hungarian consumers. This confirms previous studies that indicated ATT as most important factor to estimate BI (Januszewska and Viaene, 2001a, Stafleu et al., 1991). Moreover, both regression and correlation coefficients were positive which gives useful information to improve the current marketing communication strategy. When positive behavioural beliefs on filled chocolate are incorporated in the advertising campaign, consumers will more likely have the intention to buy filled chocolate.

As SN was only significant for Hungarian consumers, the opinion of other people seems to be important for Hungarian respondents but not for Belgian people. The latter finding is in line with previous food choice applications of TPB (Towler and Shepherd, 1991, Brewer et al., 1999, Brinberg and Durand, 1983, Thompson et al., 1994) and can be explained by the fact that in general food choice is a relatively low involvement decision. However, Tuorila (1997) stated that social factors can play an important role in the formation or change of attitudes. The result that SN is important for Hungarian respondents was expected. Within the European project 'ProPraline', focus group discussions were conducted which already revealed that filled chocolate is a luxury product in Hungary. Moreover, previous literature indicated that chocolate is a not everyday, highly valued product in central European

countries (Cidell and Alberts, 2006, Thamke et al., 2009). The opinion of friends and family, when being able to present this product, is important for the respondents. Although, when their peers see it as an unhealthy habit, the Hungarian respondents have a lower intention to eat the food product. Therefore, this confirms that in some countries the social pressure can be higher than in others (Januszezowska and Viaene, 2001a).

Corresponding with the theory, perceived behaviour control is a significant predictor of the intention of consumption of filled chocolates in the traditional TPB. Interestingly, the regression coefficient of PBC is negative which shows that a positive feeling of control has a negative influence on intention to eat filled chocolates and vice versa which is consistent with other food choice studies (Blanchard et al., 2009b, Verbeke and Vackier, 2005). When a person has a low level of self-confidence in evaluating a product consumption decision, PBC will be an issue in influencing intention. This confirms that PBC is likely to be an affecting factor in consumers' intention towards health-related behaviour (Ajzen and Timko, 1986). Hypothesis 1 is rejected as PBC has a negative influence on both Hungarian and Belgian consumers and SN is not significantly explaining behaviour for Belgian consumers.

4.5.2. TPB and anticipated emotions

Integrating anticipated emotions into the model increased the explained variance for the behavioural intention of eating filled chocolates. Moreover, both SN and PBC are no longer significantly explaining the variance in the model. Omission of the SN from the final equation is consistent with other studies based on food choice and can perhaps be explained by the fact that food choice is a relatively low involvement decision (Brewer et al., 1999). According to Thompson (1994), social influence is negligible when basic food is concerned and behaviour is primarily determined by individual preferences.

Moreover, as PBC is no longer significant, this can indicate that anticipated emotions overrule the possible control factors that might be present when intending to consume filled chocolate. Although Armitage and Conner (2001) found in their meta-analysis that PBC was highly important for BI and B, the results presented here indicate that this might be different for emotive foods such as chocolate.

The regression analysis of the model including the construct anticipated emotions confirms the stated second hypothesis that the addition of the construct anticipated emotions increases the predictive power for both countries. This confirms previous literature that emotions such as desire are an essential part of the decision making process (Moskowitz et al., 2006, Bagozzi et al., 2003).

4.5.3. Behaviour and anticipated emotions

Hypothesis 3 is confirmed for both Belgian and Hungarian consumers and thus indicates that the enactment of an intention to eat filled chocolate is influenced by anticipated emotions. The combined influence of BI and AE gives the highest predictive value. This confirms

previous statements that filled chocolate can be called emotive food or a comfort food (Wansink et al., 2003, Di Monaco et al., 2005) and that next to intention other factors are important to predict behaviour (Conner and Armitage, 1998). Moreover, the analyses indicated that the predictive value for PBC was absent for the Belgian consumers whereas for the Hungarian consumers, it did have an influence. Next to the practical need for a food product, the consumers anticipate to have specific emotions when consuming filled chocolates. This is the first study that compares the fit of the TPB model with and without the construct of anticipated emotions. The results clearly indicate that anticipated emotions both help explaining the intention to consume and the actual behaviour of consumption of filled chocolates.

4.5.4. Consumer differences between Belgian and Hungarian consumers

When developing a marketing plan, which includes the positioning of the product and knowing your customer, useful information can be gained by examining the salient beliefs that influence a person's intention to behave in a certain way and the enactment itself (Mahon et al., 2006). Moreover, Osman and Sobal (2006) indicated that cultural learning of food craving can also provide an explanation of the physiological need to eat chocolate, and Hetherington (2001) suggested that the "phenomenon of chocolate addiction" is part of the "cultural vocabulary" and thus cultural-related. The intention to eat chocolate is for Belgian consumers a trade-off between the idea of gaining weight, consuming too much sugar and control beliefs related to money on the one hand and the emotional beliefs on the other hand. For the Hungarian consumer, the opinion of relatives is a third factor that is taken into account. The behaviour in itself is very much emotion driven for Belgian consumers, whereas the Hungarian consumers can be held back due to control beliefs. Again, these results confirm previous studies that labelled chocolate as a comfort or indulgence food (Di Monaco et al., 2005).

Overall these results indicate that both nationalities need different marketing approaches. For example, convincing Belgian consumers that eating filled chocolate should not be evaluated as healthy or unhealthy but rather as an enjoyment moment, can increase the consumers' intention to eat these products. A possible example for the Hungarian is that the focus can be on a joyful shared experience with friends and family.

4.6. Conclusion

This study is relevant for the scientific field because it captures the influence of the construct anticipated emotions by comparing the model fit with and without the construct for the case of eating filled chocolates. This obtained knowledge can help a company in defining how a specific segment of consumers can be targeted by focussing on certain aspects in the marketing campaign or by developing a product that triggers the factors that makes a consumer buy a product.

However, some limitations need to be considered. First, there may have been a selection bias in the sample due to the online questionnaire which could be corrected via random selection of consumer representatives for the whole Belgian and Hungarian population. Second, some studies on TPB have included constructs such as past behaviour (Carrus, 2008) and habit (Honkanen et al., 2005) and indicated that these were important in predicting intention and behaviour. These constructs were not included in the given study as such. This could be a topic for future research as suggested by Perugini and Bagozzi (2001). Moreover, it might be interesting to include a moral dimension to the model as well. Further, the set-up of the model used in this study could be applied in future research to study if the anticipated emotions are also important in the behaviour of eating daily or healthy food products.

Further studies could be conducted in which one part would focus on anticipated emotions and another on perceived emotions. A comparison between anticipated and perceived emotions based on packaging or tasting was already conducted for chocolate by Ng et al. (2013b). This study showed that expectations and anticipated emotions based on packaging are overruled when the actual product is presented together with the packaging.

Moreover this study provides suggestions on possible differences in consumer behaviour between Hungarian and Belgian consumers related to consumption of filled chocolates.

Overall, TPB can contribute to the development of a marketing plan as it can help to define the influencing factors for the intention or the behaviour of a consumer towards a product. This study does not capture sensory data, it does provide information on the consumer and therefore it can be used at the final stage of the Stage-Gate® process to define some aspects in the marketing mix. Moreover, it can help to define which segment of consumers is targeted with the new developed product. Therefore, information on consumer behaviour can also serve as background information in the discovery stage.

As given by the results, it is important to first arouse the intention to eat filled chocolate. Moreover, to increase the transformation of intention to behaviour, marketers can try to influence emotional beliefs. This can be accomplished by applying sensory marketing which is still a topic that is not fully explored by both the academic and non-academic field (Raz et al., 2008)

Chapter 5

Effect of tasting and flavour on emotional profiles and acceptance

Adapted from:

De Pelsmaecker, S., Juvinal, J.G., Lagast, S., Schouteten, J.J., Dewettinck, K., Gellynck, X. Influence of chocolate texture on Belgian consumers' emotions and affective ratings. *In Journal of Food Quality (Under review)*

De Pelsmaecker, S., Schouteten, J., Lagast, S., Sas, B., Dewettinck, K., Gellynck, X. "Effect of tasting and flavours on the emotions and affective ratings. *(In preparation)*

Abstract

This chapter is a compilation of three studies that focused on the influence of sensory characteristics of chocolate products on the emotional profiles that consumers attribute to milk and dark chocolates.

The first experiment identified that differences in sensory characteristics of milk chocolates evoke significantly different emotional profiles and affective ratings. The second experiment was set up to compare the emotions evoked by different flavours in dark chocolates. The third experiment studied possible differences between evaluating normal dark chocolate, flavoured dark chocolate and the name 'chocolate'. This could show if tasting has an influence of the evaluation of consumers.

Further all experiments analysed the influence of gender on the emotional profiles. Next to that the possible impact of consumption frequency, prior liking of specific type of chocolate and specific attitudes towards chocolate consumption (craving and guilt) were studied.

The results showed that sensory characteristics have a significant influence on the emotional profiles whereas no difference was found between tasting and not tasting. Gender and prior liking had little to no influence. Finally, the results suggested that consumption frequency and attitudes towards chocolate did have an influence.

5.1. Introduction

Market failure of newly launched products that stood the test of consumer panels, proofs that there is more to food choice than sensory liking. Although numerous studies have measured acceptance (liking) as the main driver for preference and food choice (de Graaf et al., 2005, Drewnowski, 1997, Hellemann and Tuorila, 1991, Hetherington and Macdiarmid, 1995), recent studies show that understanding consumers' emotional responses to food additional to liking, can give new information to product developers (Cardello et al., 2012, Thomson et al., 2010, King et al., 2010, Gutjar et al., 2015). Gutjar et al. (2015) state that emotional profiles provide new information that was not captured by measuring liking and that these profiles show differences between subcategories of products. Ng, Chaya & Hort (2013a) demonstrated that data on acceptance of a product does not give a full insight in the actual acceptance. Emotional quality of a product is often a latent aspect that can be used as extra information on acceptance or as an advantage in marketing to influence purchase decision. These differentiations can provide insights for product development and marketing strategy (Jiang et al., 2014, Meiselman, 2015, Köster and Mojet, 2015).

Sensory properties are known to influence emotional response to food. Desmet and Schifferstein (2008) state that smell and taste are most often mentioned as eliciting emotions, followed by food quality and experience of eating food and anticipated consequence. Jiang, King, & Prinyawiwatkul (2014) indicate that tasting samples can lead to difference in emotion profiles as emotions can be produced, reinforced, eliminated or weakened during tasting. The effect of tasting was studied for coffee (Bhumiratana et al., 2014), chocolate (Thomson et al., 2010), blackcurrant squash (Ng et al., 2013a) and wine (Ferrarini et al., 2010). Dürschmid et al. (2006) found that for milk chocolates, taste and texture in the mouth were the most defining factors for the differentiation among the samples. Afoakwa (2010) explicitly noted that texture plays an important role in the sensory assessment of chocolate.

Given the increasing interest for the impact of food and beverages on emotions, questionnaires and other methodologies are developed to measure these emotions related to food (Cardello et al., 2012, King and Meiselman, 2010, King et al., 2010, King et al., 2013, Thomson et al., 2010, Desmet et al., 2000, Spinelli et al., 2014b). King et al. (2013) made recommendations on the impact of several parameters of their own EsSense Profile® method for emotion and hedonic responses. Several authors have used the EsSense Profile® (Piqueras-Fiszman and Jaeger, 2014a, Jaeger and Hedderley, 2013, Jaeger et al., 2013), compared this method with the their own or other scales (Spinelli et al., 2014b, Ng et al., 2013a, Dalenberg et al., 2014, Gutjar et al., 2015) but also questioned the working of this method (Jiang et al., 2014, Thomson and Crocker, 2014). Jiang et al. (2014) stated that the method might miss some important emotions as the terms are pre-defined and the differences among food products can be large. However, the method has been used and been found to work for chocolate products which is the food product studied in this research.

Measuring emotional profiles of products is influenced by the characteristics of the participants. Jiang et al. (2014) identified seven of these characteristics that have an effect on emotions namely physical state (hunger, thirst and fatigue), psychological state and mood of the respondents (Desmet and Schifferstein, 2008), different attitudes and evaluation towards food (Jiang et al., 2014), cultural differences (Ferdenzi et al., 2011), liking effect (Rousset et al., 2005), gender (King et al., 2010) and product familiarity (King and Meiselman, 2010). This chapter will focus on gender, liking effect and attitudes towards the product.

A study of King et al. (2010) indicated that women can be emotionally more sensitive to food than men although this is product specific. For example, the choice of “comfort food” shows gender and age specificity (Wansink et al., 2003). Women identify sweet snack foods (i.e. chocolate, ice cream) as comfort foods, while men selected savoury meal-related foods (i.e. steak, casseroles) and younger people preferred more snack-related comfort foods compared to people who are older than 55 years. Further, for carbonated beverages, emotions are influencing food acceptability for males but not for females (Jiang et al., 2014). It can be argued that the difference between genders is product specific as Gutjar et al. (2015) found no differences in emotion ratings between males and females for breakfast drinks. Differences between males and females was further studied by Jaeger and Hedderley (2013) based on the statement from Diener et al. (1985) that the experience of emotions is generally more pronounced for women than men. Finally, it can be hypothesized that females will report feelings of guilt and being unhealthy when consuming comfort foods. Further, women are known to express their feelings more openly than men (King et al., 2010).

The effect of liking was studied by Rousset et al. (2005). The authors found that low frequency meat eating women generally have more disappointment, indifference and doubt towards red meat than the high frequency meat eating women. King and Meiselman (2010) indicated that products which are equally accepted do not always have similar emotion ratings. This was confirmed by Bhumiratana et al. (2014) for coffees. Several studies showed that emotional profiles can be used to make distinctions between different products instead of using only liking scores (Cardello et al., 2012, Ng et al., 2013a, Spinelli et al., 2014b). Moreover, it was identified that emotional profiles can help in predicting food choice together with liking (Dalenberg et al., 2014, Gutjar et al., 2015).

In the study from Jaeger and Hedderley (2013), the relationship between intensity of emotion ratings and scores on the emotional intensity scale (EIS-R) and the private body consciousness scale was studied. They suggest that if gender differences are studied it could be useful to let the respondents fill in a supplementary questionnaire to probe their attitude ratings. These results could enlighten the researchers on the nature of for example gender differences. Although some emotions are intuitive, others can be related with an attitude towards a product. Piqueras-Fiszman and Jaeger (2014b) used the Dutch Eating Behaviour Questionnaire (DEBQ) to determine if individual differences regarding behaviours influence the emotional responses. They found that for chocolate brownies, differences between the

three groups defined by DEBQ were significant. The results were similar to the findings of Jaeger and Hedderley (2013), although the results were only reproduced for chocolate brownie and not for an apple. Again, the effect of comfort food cannot be underestimated. A study conducted on attitude towards food by Macht and Mueller (2007) showed that negative emotions improved after eating palatable chocolate. This effect was most pronounced in persons scoring high on emotional eating but lasted only for three minutes.

Cardello et al. (2012) found that for highly emotionally laden food items, such as chocolate, respondents had a more intense emotional response towards the name than towards the tasted product. Further, the study suggests that the reliability of emotion responses toward food names is more consistent over time than the response formulated based on tasting. Food names are possibly reflecting a stable and broader image and association whereas tasting is depending on the influencing factors as described above (King et al., 2013, Cardello et al., 2012). Tasting can create a vivid response, but the reliability can be less stable (Jiang et al., 2014).

Thus, the aim of this chapter was to investigate the impact of several influencing factors on consumers' emotion responses to different subcategories of a product sample. The specific objectives were: (1) To study if significant different sensory profiles evoke significantly different emotional profiles and affective ratings (2) To compare the emotions evoked by foods with different flavours and if there is a difference between actual tasting or only verbal description of the product (3) To investigate whether the emotion profiles of food are influenced by gender (4) To explore whether liking or frequency of consumption of the food exert any impact on the emotional profiles and (6) To examine if difference in attitude towards chocolate (craving, guilt or functionality) is related to difference in the emotional profiles of the consumers.

5.2. *Materials and methods*

This chapter consisted of three experiments for which milk chocolates (experiment 1) and dark chocolates (experiment 2 and 3) were used as samples. Milk and dark chocolates were chosen for these experiments, as stimuli, as previous studies reported that they elicit sensory and emotional responses (Cardello et al., 2012, Thomson et al., 2010, Thamke et al., 2009).

5.2.1. Experiment 1

The overall objective of the first experiment is to examine the influence of the sensory characteristics of milk chocolate on Belgian consumers' emotions and affective ratings (e.g. overall acceptance and attribute liking of chocolate). The physical characteristics of the selected chocolates were discussed in the third study in Chapter 3. Here, the EsSense Profile® Methodology is used to determine the emotions associated with the different types of milk chocolate. Then, correlations are used to define how emotion data can provide insight in the affective response.

5.2.1.1. *Subjects*

A total of 131 respondents participated in the experiment at the SensoLab. These consumer were randomly recruited at Ghent University. As indicated in chapter 3, some selection criteria were defined: (1) regular consumers of chocolate; (2) do not have a specific disliking for chocolate; (3) do not have any known food allergies or dietary intolerance; (4) willingness and availability to participate in the experiment.

5.2.1.2. *Samples*

As already indicated in chapter 3, three milk chocolate were selected as they were part of three segments of chocolate products in Belgium: chocolate from premium brand (PB), a chocolate available under private label (PLB) and a traditional type of chocolate which is originally produced and originated in Belgium) (TB). It should be noted that the term 'traditional' does not refer to 'handmade'. The chocolate used in this experiment for TB is industrially manufactured. Further description of these chocolates can be found in third study of chapter 3.

5.2.1.3. *Consumer test*

Respondents were seated in individual booths. They were given a brief instruction about the procedure of the test. The chocolate samples were randomised and were presented monadically. The labels and brands of the chocolate samples were removed and the chocolates were placed on plastic plates with random 3-digit codes before serving to the respondents. The preparation was executed 10 minutes before the evaluation to avoid prolonged exposure to air and environment. The respondents received table napkins and were encouraged to drink some still mineral water in between samples to cleanse their palate

and have some rest. The average time for a respondent to complete the evaluation was 10 minutes.

5.2.1.4. Construction of the test

The questionnaire was composed of four parts. First, the respondents were asked to taste the chocolate and rate their overall liking for each product, using a nine-point hedonic scale (Lawless and Heymann, 2010).

Second, they needed to indicate their emotional responses using check-all-that-apply (CATA) method on the associated consumer-defined lexicon by King, Meiselman & Carr (2010) in the EsSense Profile® Methodology. The EsSense Profile® method was developed by King et al. (2013). In this questionnaire, the emotions are presented in alphabetical order (Cardello et al., 2012, Richins, 1997). The EsSense Profile® method includes a list of 39 terms determined by King and Meiselman (2010). The list included 25 positive, 3 negative and 11 unclassified emotions (Ng et al., 2013a). The label unclassified was given to the terms for which more than 50% of the participants had rated them as neither positive nor negative. The respondents were asked to check or tick all the terms that describe how they feel just after consuming the chocolate sample.

Third, they were asked to indicate in a 'just about right' (JAR) scale their perception of the texture attributes of the chocolate. This last part was already discussed in chapter 3. Finally, information on demographics and patterns of chocolate consumption were collected through a questionnaire after the chocolate evaluation.

5.2.1.5. Determination of the sensory profile of chocolate

By conducting QDA, the sensory profiles of the three selected chocolates was defined. These sensory profiles can be found in section 3.4.2.3. The results of the emotional profiling is correlated to the results of the sensory profiling in this experiment to study if sensory characteristics can evoke specific emotions.

5.2.1.6. Data analysis

A comparison of categorical data for the emotions associated with the different chocolate samples was performed using the Cochran's Q Test for each emotion in SPSS. Pairwise comparison between the brands for each emotion was done using the McNemar Test in SPSS. Correspondence Analysis (CA) was performed on the average frequency of the 39 emotions for each type of chocolate in order to identify the relationships between the emotion terms and the products as suggested by Ng et al. (2013a).

To determine the relationship between the overall acceptance and the emotional responses of each chocolate sample, Partial Least Square Regression (PLSR) was performed on the mean overall liking scores and the average frequency data. A Weighted Regression Coefficient figures were produced for overall acceptance and emotional responses that show the 'drivers of liking' or the emotions that negatively or positively correlate with overall acceptance (XLSTAT Version 2013.4.05, Addinsoft, USA).

To assess if acceptability and emotions are influenced by gender and type of chocolate they prefer (milk chocolate vs. dark and white), the data from consumer testing was grouped accordingly. T-test was used to compare the two groups while ANOVA was used to determine significant differences in acceptability within the group. For emotions, Cochran's Q Test was used to differentiate the samples in each group. Furthermore, a Pearson product-moment correlation and Principal Component Analysis were run to determine the relationship between the sensory attributes and instrumental evaluation. All these analyses were run in IBM SPSS Statistics 20.

5.2.2. Experiment 2

The second experiment focused on differences between the emotional responses elicited by two dark chocolates with different flavour varieties. The influence of socio demographic factors on the emotion profiles was also studied in this experiment.

5.2.2.1. Subjects

A total of 156 chocolate consumers participated in the experiment. After data clearing, a total of 149 valid responses were used for analysis. Data were deleted if the questionnaires were not completed. These respondents were recruited at Ghent University through convenience sampling. The only selection requirement was that the respondent was a chocolate consumer.

5.2.2.2. Samples

Jager et al. (2014) found that adding a flavour such as mint or orange to plain chocolate elicits a shift from texture to flavour attributes as the most salient in the sensory space. This causes the pleasantness dimension to be dominant instead of the arousal dimension (Jager et al., 2014). Thus, two products were selected that had clear distinctions in flavour, mint and orange flavoured chocolate, while other sensory cues were kept constant. Similar to the study of Jager et al. (2014), the chocolates were selected from the Lindt Excellence series (Intense Mint and Intense Orange).

The chocolates were cut in squares (2cm by 2cm) and wrapped in aluminium foil. The code of the sample was written on the surface of the foil. Two pieces of each chocolate were provided to prevent that the respondent did not have enough chocolate to complete the questionnaire.

5.2.2.3. Consumer test

The respondents received two chocolate samples and questionnaire at the UGent SensoLab and were instructed to fill in the questionnaire at home. One week later they could bring in the completed questionnaire at the SensoLab. This home-use-test was applied as the consumers could do the evaluation in more natural circumstances (Lawless and Heymann, 2010, Stone and Sidel, 2004c, Stone et al., 2009). This test was designed as a home-use test (HUT) (Lawless and Heymann, 2010, Stone and Sidel, 2004c, Stone et al., 2009). A HUT is

considered to be the most realistic approach when evaluating food products. However, it is also the most expensive, time-consuming and open to bias. This HUT test is important for advertising claim support as it is often used to evaluate not only sensory characteristics but also extrinsic characteristics such as packaging or convenience (Lawless and Heymann, 2010).

5.2.2.4. Construction of the test

The first part of the questionnaire was constructed to identify the consumption habits of the respondents (frequency, context, preference for type of chocolate).

Consumers were asked to rate their overall liking for both chocolate on a seven-point hedonic scale with "1 = extremely dislike" and "7 = extremely like". This was performed prior to giving their emotional responses using the EsSense Profile® method identical to experiment 1. However, here the emotions were rated on a five-point scale anchored with "not at all" and "extremely" (King and Meiselman, 2010). After the pre-test with ten persons, most of the participants indicated that the emotion 'whole' was difficult to understand and to differentiate from 'satisfied'. Therefore, the researchers decided to delete 'whole' from the questionnaire and to work with 38 emotional terms.

Finally socio-demographic questions were asked (gender, age, financial state, education, length and weight).

5.2.2.5. Data analysis

Data were analysed using SPSS 21.0. Bivariate analyses through comparison of mean scores were used to find significant differences. Paired sample t-test was used to find significant differences in overall liking and emotion ratings of both chocolates. To assess the relationship between liking and emotional responses, Pearson correlation coefficients were determined between mean overall liking scores and EsSense Profile® ratings. Independent sample t-test was used to find the significant differences between genders, paired sample t-test for differences within gender. Further, one-way ANOVA was used with LSD post hoc comparison of mean scores to assess association between the interval scaled emotions and the categorical scaled variables preference and user frequency. A p-value of 0.05 was used for each statistical test performed.

5.2.3. Experiment 3

As the second experiment focused on two different added flavours to dark chocolate, this experiment used two chocolates of which one was the standard dark chocolate and the second a chocolate with an added flavour to again study the influence of flavour. Next to the two groups who had to taste a different chocolate, a third group was included to study the effect of the wording 'dark chocolate' on the emotional profiles. Cardello et al. (2012) already studied the difference in response towards a name or tasting of a product.

As discussed in the introduction, liking can have an effect on the emotional profiles that is given to the products by the consumers. Further attitude profiles of the consumers are also

taken into account to explain the emotional profiles. If the attitude towards chocolate is related to guilty feelings, it might evoke more negative emotions whereas an attitude of craving can elicit rather positive emotions.

5.2.3.1. *Subjects*

At the Ghent University stand at a local food fair, visitors of the fair were asked to participate in a consumer test on chocolate. This was a convenience sampling although there were two selection criteria: not allergic to chocolate and regular chocolate consumer. Further, the participants were informed that they were randomly assigned to a booth which all had a different questionnaire. The respondents were informed that if they were sorted in the group that did not had to taste a chocolate during the questionnaire, they would receive a piece of chocolate to take home after completing the questionnaire. Moreover, they were informed that if they completed the questionnaire, they would receive a coupon for a free consumption at the exhibition stand as an incentive.

A total of 930 consumers participated in the experiment and only 20 answers were discarded due to missing data.

5.2.3.2. *Samples*

In this experiment, again two dark chocolate with different flavours were used. Similar to experiment 1, the products were selected from one single producer (Belgian chocolate producer, Daskalidas) in order to keep the sensory cues next to flavour similar. The researchers chose for regular dark chocolate and dark chocolate with raspberry flavour.

5.2.3.3. *Consumer test*

The group was divided in three groups. The first group tasted dark chocolate, the second raspberry flavoured dark chocolate and the last group did not taste anything. The participants were randomly assigned to a booth. Due to practical reasons, only five booths were available which caused an unbalanced distribution of the respondents over the three groups. 357 respondents tasted dark chocolate, 358 tasted raspberry flavoured chocolate and 195 conducted the questionnaire without tasting. This study was a central location test (CLT) (Lawless and Heymann, 2010, Stone and Sidel, 2004c, Stone et al., 2009). Literature indicates that CLT can be set-up in a variety of places (Resurreccion, 1998). In this study, the CLT took place at a food festival open for everyone. Compliance with instructions, manner of examining samples, and ways of responding were being monitored and controlled. Respondents were positioned in separate areas with laptops to evaluate the products. Although a CLT test allows the researcher to have more control over the setting when evaluating the product, the downside of this test is the short exposure to the product and the unrealistic situation. This should be taken into account when coming to a conclusion based on the collected data.

5.2.3.4. *Construction of the test*

The first questions probed the chocolate preference and frequency of chocolate consumption. For the two groups in which respondents needed to taste chocolates, the consumers were given this instruction to taste and asked to rate their liking on 9-point hedonic scale with "1= extremely dislike" and "9= extremely like". Further they were asked to rate the intensity of 24 emotions. This list of emotions was sampled from focus groups (n=19) in which emotions related to chocolate were discussed. A similar approach was used by Thompson et al. (1994). The list of emotions from the EsSense Profile[®] method (King and Meiselman, 2010) was used to start the discussion. Participants of the research could delete or add emotions. The final list included 24 emotions. Again, emotions were presented in alphabetical order and respondents had to rate the intensity of the emotions on a 5-point scale anchored with "1=not at all" and "5=extremely" were used (King and Meiselman, 2010). The group of respondents who did not had to taste chocolate, did obviously not rate their acceptance but only rated the emotions. The same 24 emotions and scale were used together with the preliminary question: "Rate the intensities of emotions that you normally experience while eating a piece of dark chocolate?"

Further, the consumers were asked to answer the Attitude to Chocolate Questionnaire (ACQ) (Benton et al., 1998). Benton et al. (1998) developed a measurement scale specifically to register attitudes towards chocolate consumption. This scale, termed the Attitude to Chocolate Questionnaire (ACQ), has been validated by Müller et al. (2008) and used in several other studies (Fletcher et al., 2007, Cramer and Hartleib, 2001). The ACQ evolved to a widely used tool to enlarge the knowledge about the influencing factors and consequences of eating chocolate. The ACQ assesses three factors associated with attitudes of consumers. The first factor "craving", assesses craving for chocolate and the tendency to seek comfort from chocolate under emotionally stressful conditions, the second factor, "guilt", measures negative feelings associated with eating chocolate and dissatisfaction with weight and body image, and the third factor, "functional", reflects a functional approach, such as eating chocolate to gain energy (Benton et al., 1998, Müller et al., 2008, Hormes and Timko, 2011). The ACQ contains 24 statements representing the three predefined factors craving, guilt and functional (Benton et al., 1998). All statements are rated on a 7-point hedonic scale from "Totally disagree" to "Totally agree" with the preceding question "To what extend do you agree with the following statements?". Finally, the respondents were asked to give their gender, age and indicate if they look at their weight.

5.2.3.5. *Data analysis*

Data were analysed using SPSS 21.0. Bivariate analyses through comparison of mean scores were used to find significant differences. Paired sample t-test was used to find significant differences in overall liking and emotion ratings of both tasted chocolates. To assess the relationship between liking and emotional responses, Pearson correlation coefficients were determined between mean overall liking scores and emotions ratings. Further, one-way ANOVA was used with LSD post hoc comparison of mean scores to assess differences

between the treatment (not tasting, dark chocolate tasting, raspberry tasting) and the emotional ratings. Further, two-way ANOVA (general linear model with two factors) with Tukey post hoc comparison, was performed on the appropriateness ratings considering treatment, gender, and their interaction as explanatory variables to examine their effect on the emotion ratings. One-way ANOVA was used to further identify the significant differences between genders and within gender. A similar procedure was used to identify significant differences for preference and user frequency.

Exploratory factor analysis (EFA) using principal components and varimax rotation, was used to identify the factors and factor loading. The Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure for sample adequacy showed that the data was suited for factor analysis. A construct reliability test with Cronbach alpha statistics is performed to check the reliability of the ACQ scales. Threshold value for a satisfactory construct is 0.6, which denotes that the different items measure one single construct and therefore may be aggregated. Aggregation was done through averaging the scores across items assigned to a specific factor. Hierarchical clustering with Ward's Method as cluster method and K-means cluster analysis were performed on the aggregated factor scores. The clusters were used as independent factor together with treatment in the two - way ANOVA. The same analyses were conducted as for finding gender differences.

5.3. Results

5.3.1. Experiment 1

5.3.1.1. Sensory profiles of the three milk chocolates

The results of the sensory profile was thoroughly discussed in study 3 of Chapter 3. Twelve out of the 15 attribute descriptors that were used are discriminators between the different chocolate products (Table 5. 1). This implies that the trained panel can find differences in sensory attributes of the chocolate samples through QDA.

Table 5. 1: Mean values for intensity scores of the chocolate samples on the different sensory attributes by QDA (cfr table 3.12)

Attribute	Premium brand	Private label brand	Traditional brand
Colour	9.6 ^a	6.0 ^b	4.4 ^c
Gloss	9.6 ^b	7.6 ^c	10.7 ^a
Cocoa aroma	9.1 ^a	7.2 ^b	4.7 ^c
Caramel aroma	4.5 ^b	5.7 ^b	6.5 ^a
Vanilla aroma	3.3 ^a	4.5 ^a	4.6 ^a
Milky aroma	4.6 ^{bc}	6.1 ^{ab}	6.6 ^{ab}
Snap	9.5 ^a	7.3 ^a	6.3 ^b
Hardness	8.7 ^a	7.8 ^a	4.4 ^b
Sweetness	8.6 ^a	9.8 ^a	10.0 ^a
Bitterness	4.7 ^a	1.7 ^b	0.9 ^b
Grittiness	2.7 ^b	3.2 ^b	8.4 ^a
Creaminess	9.2 ^a	8.9 ^a	6.3 ^b
Rate of melting	6.5 ^a	7.5 ^a	7.6 ^a
Oily film	8.7 ^a	7.8 ^a	4.4 ^b
Residual	3.2 ^b	3.3 ^b	6.7 ^a

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

5.3.1.2. Consumer Testing

Socio-demographic characteristics of respondents

From the 131 respondents who participated in the consumer test in the SensoLab, 127 completed the questionnaire. The incomplete questionnaires were eliminated from the dataset. The consumer sample was composed of 70 (55.12%) females and 57 (44.88%) males. As these consumers were recruited at Ghent University, 92.06% of the respondents are between the age 18-25 followed by 3.17% between 26-30 years old. Similarly, the majority are students (88.89%). More than half of the respondents (57.94%) prefer milk chocolate followed by those who prefer dark chocolate (27.78%) and finally those who prefer white chocolate (13.29%).

Overall acceptance

Based on all respondents, PB scored significantly higher (6.92) in overall acceptance compared to PLB (6.19) and TB (4.72). When grouping the respondents based on their

chocolate type preference (white, milk or dark), as milk chocolates were used in this experiment, all the respondents who indicated that they prefer milk chocolate were grouped together (n=73) and the respondents that preferred other types of chocolate were grouped (n=53). The same trend for overall acceptability (PB>PLB>TB) was found for respondents who prefer milk chocolate and those who prefer other types (dark and white). For each type of chocolate, the two groups did not differ in the level of their liking for PB, PLB and TB.

The acceptability of the three chocolate did not differ between male respondents (n=56) and female respondents (n=70). Moreover, same trend for overall acceptability (PB>PLB>TB) was found for male and female respondents. Thus, acceptability for each type of chocolate was not influenced by gender or the type of chocolate they prefer.

EsSense Profile® Methodology: Consumer emotion measurement

Fourteen out of 39 emotions from the EsSense Profile® list discriminated the three brands (Table 5. 2). Ten of them were positive emotions ('energetic', 'enthusiastic', 'glad', 'happy', 'merry', 'nostalgic', 'pleased', 'pleasant', 'satisfied' and 'warm'), two were negative ('bored' and 'disgusted') and two had no clear classification ('daring' and 'wild') (King and Meiselman, 2010). Pairwise comparison for each emotion makes it possible to explore the differences among the samples.

The positive emotions 'happy', 'friendly', 'good', 'merry' and 'pleasant' have a relatively high (40-60%) frequency count. The chocolate samples were not significantly different from each other in terms of these emotions. Significantly higher average frequency were obtained by PB (53) and PLB (44) for the positive emotion 'glad' compared with TB (32). The same trend is observed for the positive emotion 'pleased'. PB showed to be superior in terms of positive emotions 'happy', 'warm', 'enthusiastic', 'energetic' and 'satisfied', obtaining significantly higher frequency count (40-60) than the other two chocolates which were more or less 10 counts lower. PLB however, did not differ significantly from PB with the positive emotion 'merry'. In terms of negative emotions, TB was found to be significantly higher in terms of 'bored' (22) and 'disgusted' (16) compared with the other two chocolate samples. Female respondents showed differences in different emotions ('bored', 'disgusted', 'enthusiastic', 'happy', and 'wild') than male respondents ('bored', 'glad', 'merry' and 'pleasant').

Table 5. 2: Comparison of emotions associated with chocolate samples (frequency count)

Emotion	Overall			Male			Female		
	PB	TB	PLB	PB	TB	PLB	PB	TB	PLB
Active ⁺	24	15	22	11	9	9	13	6	13
Adventurous ⁺	13	7	6	6	4	3	7	3	3
Affectionate ⁺	14	14	13	4	6	2	10	8	11
Aggressive ^u	2	2	2	0	1	1	2	1	1
Bored ⁻	4 ^b	22 ^a	13 ^b	2 ^b	12 ^a	3 ^b	2 ^b	10 ^a	10 ^a
Calm ⁺	46	53	48	16	24	22	30	29	26
Daring ^u	8 ^a	1 ^b	4 ^b	3	1	2	5	0	2
Disgusted ⁻	4 ^b	16 ^a	12 ^b	3	8	4	1 ^b	8 ^a	8 ^a
Eager ^u	12	5	9	4	1	4	8	4	5
Energetic ⁺	25 ^a	9 ^b	18 ^a	11	4	7	14	5	11
Enthusiastic ⁺	39 ^a	20 ^c	31 ^b	15	9	14	24 ^a	11 ^c	17 ^b
Free ⁺	19	17	18	8	9	8	11	8	10
Friendly ⁺	43	48	38	20	25	18	23	23	10
Glad ⁺	53 ^a	32 ^b	44 ^a	26 ^a	14 ^b	25 ^a	27	18	19
Good ⁺	61	60	58	28	24	26	33	36	32
Good-natured ⁺	22	19	25	11	11	11	11	8	14
Guilty ^u	7	9	9	2	4	4	5	5	5
Happy ⁺	52 ^a	34 ^b	37 ^b	23	15	20	29 ^a	19 ^b	17 ^b
Interested ⁺	18	16	23	7	8	10	11	8	13
Joyful ⁺	22	15	17	11	6	10	11	9	7
Loving ⁺	12	14	12	5	6	5	7	8	7
Merry ⁺	46 ^a	24 ^b	27 ^{a,b}	23 ^a	8 ^b	14 ^b	23	16	13
Mild ^u	11	20	19	7	9	6	4	11	13
Nostalgic ⁺	7 ^b	18 ^a	7 ^b	3	8	2	4	10	5
Peaceful ⁺	26	24	24	10	7	11	16	17	13
Pleasant ⁺	44 ^a	28 ^b	46 ^{a,b}	21 ^a	11 ^b	25 ^a	23	17	21
Pleased ⁺	60 ^a	40 ^b	57 ^a	29	20	30	31	20	27
Polite ^u	19	29	19	10	14	7	9	15	22
Quiet ^u	26	24	23	9	12	12	17	11	11
Satisfied ⁺	42 ^a	24 ^b	30 ^{a,b}	17	9	14	25	15	16
Secure ⁺	7	8	5	2	3	3	5	5	2
Steady ^u	10	3	9	1	2	3	9	1	6
Tame ^u	13	12	15	6	6	3	7	6	12
Tender ⁺	17	22	16	7	8	8	10	14	8
Understanding ^u	11	18	14	6	8	6	5	10	8
Warm ⁺	38 ^a	22 ^b	24 ^b	21	11	12	17	11	12
Whole ⁺	7	2	6	3	0	3	4	2	3
Wild ^u	7 ^a	2 ^a	0 ^b	1	0	0	6 ^a	2 ^a	0 ^b
Worried ⁻	7	10	10	2	5	3	5	5	7

⁺ Positive, ⁻ negative, ^u no clear classification based from King and Meiselman (2010)

^{abc} Means not sharing the same letter superscripts within a row are significantly different ($P \leq 0.05$) based on McNemar Test; n=126

5.3.1.3. Correlation between emotions and overall acceptance

Figure 5. 1 shows the bi-plot of the correlation between emotions and overall acceptance. The graph shows two dimensions in which dimension 1 accounted for 85.5% of variance of the data and dimension 2 accounted for 14% of variance. The plot shows the product positioning in the emotional space (Figure 5. 1).

The most liked product, PB, is positioned with mostly positive emotions – ‘joyful’, ‘happy’, ‘merry’ and ‘adventurous’ but also the unclassified emotion ‘daring’. Meanwhile, PLB is strongly associated with positive emotions such as ‘pleasant’, ‘good-natured’, ‘active’, ‘steady’ and ‘whole’. Finally, most of the negative emotions are related to TB such as ‘bored’ and ‘disgusted’. However, it has also its share of some positive emotions such as ‘calm’, ‘tender’ and ‘friendly’. TB is the chocolate to which the emotion ‘nostalgic’ is mostly correlated. It could be argued that nostalgia is difficult to grasp for respondents from this age, however Bambauer-Sachse & Gierl (2009) indicated in their study on nostalgia in advertising that positive effects of nostalgic advertising do not necessarily depend on the age of the advertising recipients.

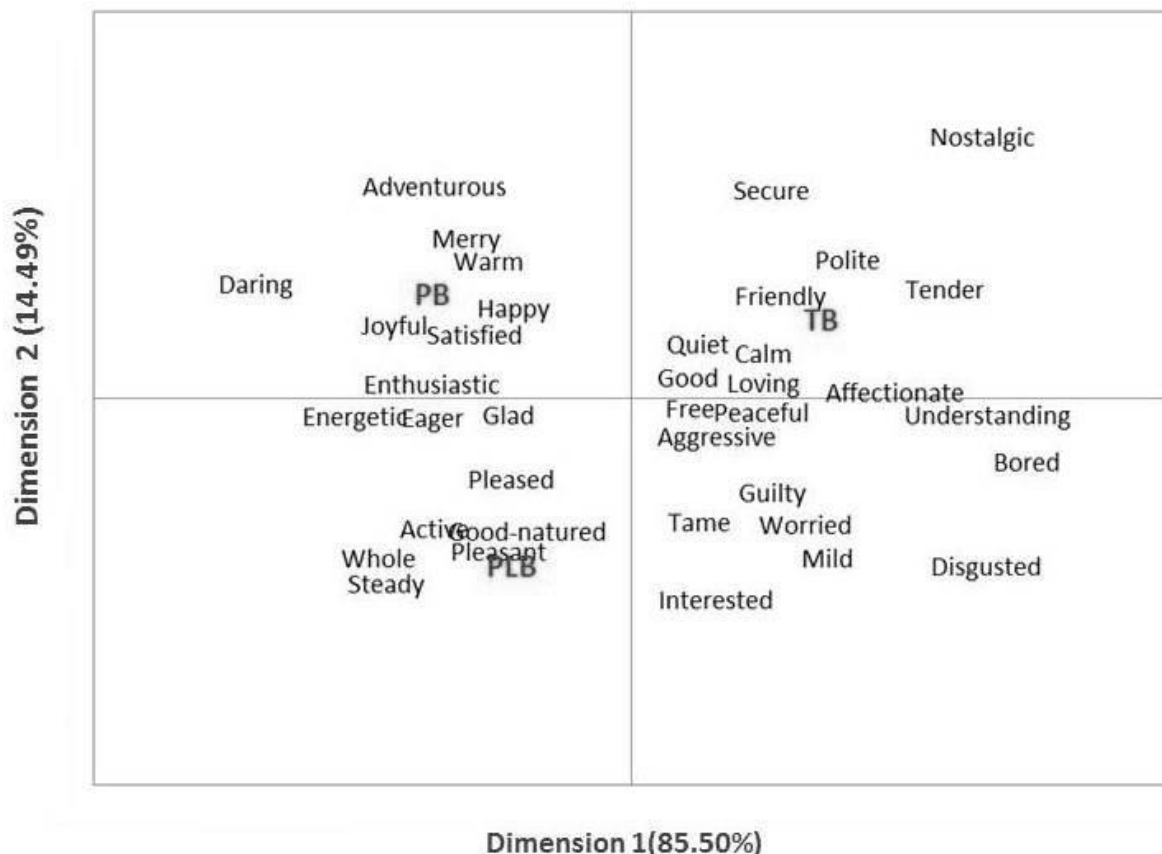


Figure 5. 1: Correspondence Analysis emotion-product symmetric plot (Dimension 1 vs. Dimension 2) obtained from EsSense Profile® total frequency counts

The PLS regression is the most appropriate multivariate regression method available to find a function of the predictive variables (here emotions) that best describe the variation in the

hedonic data (Meullenet et al., 2007) (section 3.4.3.3). Figure 5. 2 depicts the weighted regression coefficients and the confidence intervals for these coefficients. Some confidence intervals are wide and include zero. This indicates an overfitting problem what means that it includes random noise in the specific samples. This overfitting may be due to the large number of variables (39 emotions) (Meullenet et al., 2007). This can be improved by selecting a priori the most important emotions only to reduce the number of predictors and obtain a better fit. But with the current output, at least we see the influence of all the 39 emotions of the EsSense® profile. The weighted regression coefficients (WRCs) indicate the role of a variable in the prediction of overall liking. Variables with positive WRCs are referred to as positive drivers of liking while variables with negative WRCs are usually referred to as negative.

The weighted regression coefficients (Figure 5. 2) show that positive 'drivers of liking' are mostly positive ones: '*energetic*', '*enthusiastic*', '*free*', '*glad*', '*happy*', '*joyful*', '*pleased*', '*satisfied*', '*whole*'; but also some unclassified emotions: '*daring*', '*eager*', and '*steady*'. As expected, these emotions are mostly correlated with the Premium Brand (see Figure 5. 1) which explains its highest overall acceptability. Further, the negative drivers for liking are '*bored*', '*calm*', '*disgusted*' and '*understanding*'. However, there are some emotions that can have a positive or a negative effect. This can be due to the overfitting but could also indicate that the influence of some emotions is depending on factors such as environment, personal characteristics, and many others.

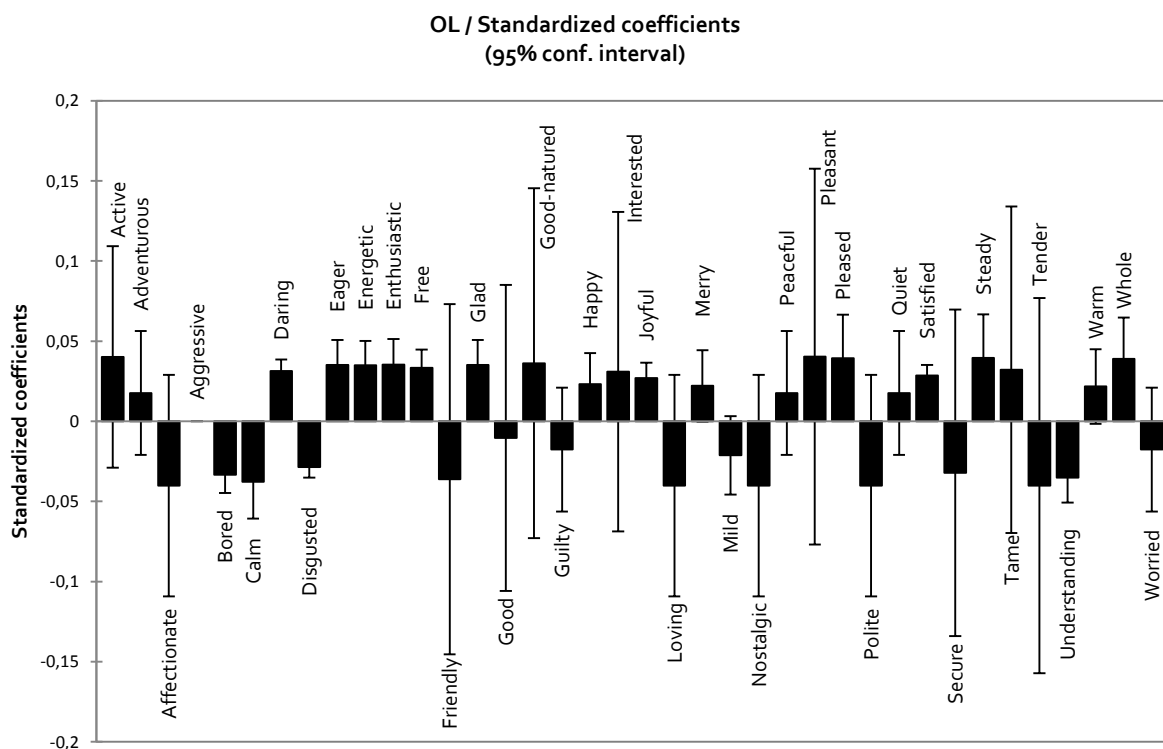


Figure 5. 2: Weighted regression coefficients for emotions predicting overall liking of chocolates based on Partial Least Square Regression

5.3.2. Experiment 2

5.3.2.1. *Different flavours result in different emotional profiles*

Overall liking scores

A paired samples t-test was carried out on liking scores of the 2 chocolate samples in all subjects (n=149). Significant differences were found in consumers' overall liking for the products ($p < 0.001$). The mint flavoured chocolate was found to be the least liked (4.0) while orange flavoured chocolate was most liked product (5.1).

Emotional profiles

Figure 5. 3 shows the mean emotional responses to the orange chocolate and mint chocolate. On 25 of the 38 emotion terms, a significant difference was found between the chocolates. For 24 of these emotions, the magnitude of the emotion response to the orange chocolates was greater than to the mint chocolate with the only exception for '*disgusted*'. This is different from Cardello et al. (2012) who did not find significant differences in the emotional profile for the same product with different flavours. The lowest scores were found for '*aggressive*', '*bored*', '*guilty*', '*wild*' and '*worried*'. For these five emotions, the mean for both chocolates is lower than 2. It must however be noted that the intensity of the emotions was rather moderate and only one emotion was rated higher than 3 ('*good*') for the orange chocolate.

Correlations were calculated between the liking ratings for the two products and each of the 38 emotion term ratings. Table 5. 3 shows the significant correlations. As can be seen, emotions with positive valence were positively correlated to liking whereas the emotions with negative valence such as '*aggressive*', '*bored*', '*disgusted*', '*guilty*' and '*worried*' were negatively correlated to liking.

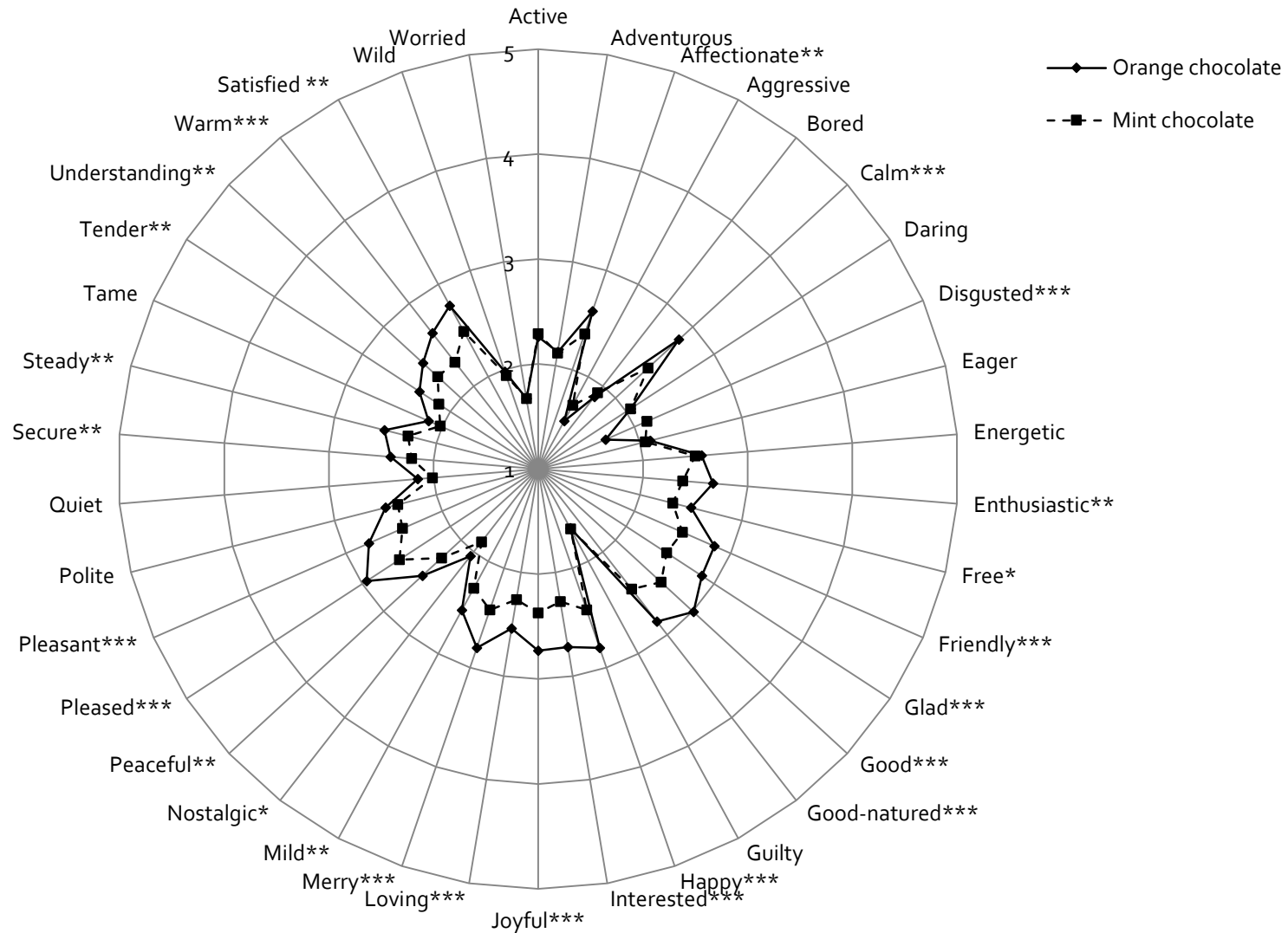


Figure 5. 3: Mean emotional responses to the orange and mint flavoured chocolate.

Significant difference is indicated: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$

Table 5. 3: Significant correlation coefficients (Pearson r) between emotion ratings and liking ratings for both chocolates.

	Orange chocolate	Mint chocolate
Active	0.162*	0.366***
Adventurous	0.140*	0.275***
Affectionate	0.258**	0.399***
Aggressive	/	-0.250**
Bored	-0.252**	-0.287***
Calm	/	0.140*
Disgusted	-0.645***	-0.602***
Eager	0.155*	0.280***
Energetic	0.267**	0.407***
Enthusiastic	0.377***	0.429***
Free	0.283***	0.222**
Friendly	0.199**	0.288***
Glad	0.360***	0.338***
Good	0.446***	0.421***
Good-natured	0.233**	0.230**
Guilty	/	-0.154*
Happy	0.261**	0.314***
Interested	0.301***	0.401***
Joyful	0.331***	0.317***
Loving	0.206**	0.238**
Merry	0.283***	0.305***
Mild	0.163*	0.170*
Nostalgic	/	0.081*
Peaceful	0.152*	0.156*
Pleased	0.386***	0.493***
Pleasant	0.390***	0.360***
Polite	/	0.157*
Secure	/	0.137*
Steady	/	0.213**
Tender	0.198**	/
Warm	0.198**	0.252**
Satisfied	0.374***	0.424***
Worried	-0.361***	-0.199**

Significant difference is indicated: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$

5.3.2.2. Influence of gender

The results of experiment 1 show that there are no significant differences between the emotional profiles given by males and females for the orange and mint chocolate.

When looking at the emotional profiles given by the men for the two types of chocolate, significant differences are found. Figure 5. 4 shows that men give significant higher ratings to the orange sample except for 'aggressive'. Mint flavour seems to arouse this emotion more than orange flavour. The other 20 emotions for which a significant difference exists are all positive emotions. The emotional profiles that women give to both types of chocolates is also

significantly different for 19 emotions (Figure 5. 5). Again for only one ('*disgusted*'), the mint chocolate has a higher value than the orange chocolate. The 18 other emotions are all positive emotions.

Comparing Figure 5. 4 and Figure 5. 5 shows that the significant differences in emotional profiles given by both genders is different. For men, there are 21 significant difference and 19 for women. The mint flavour is associated with aggressive according to the male respondents and with disgusted for the female respondents. On the one hand, the male respondents indicated significant differences for '*affectionate*', '*mild*', '*nostalgic*', '*peaceful*' and '*understanding*' which were not present for the females. On the other hand, females indicated that '*secure*', '*steady*' and '*tender*' discriminate between the two chocolates. All respondents are in agreement that '*calm*', '*enthusiastic*', '*friendly*', '*glad*', '*good*', '*good-natured*', '*happy*', '*interested*', '*joyful*', '*loving*', '*merry*', '*pleased*', '*pleasant*', '*warm*' and '*satisfied*'.

5.3.2.3. *Influence of preference and user frequency*

It was stated that personal preference for a type of chocolate can influence the emotional profiles. Therefore, ANOVA tests were conducted to find difference between the emotional profiles of consumers with a different preference for white, milk or dark chocolates. For the orange chocolate, no significant differences were found. For the mint chocolate, significant differences were found for only two emotions, '*secure*' and '*understanding*'. '*Secure*' received the highest score from the dark chocolate consumers (2.6^a), followed by the white chocolate (2.3^{a,b}) and finally milk chocolate consumers (1.2^b). The intensity of the emotion '*understanding*' is again highest for the dark chocolate consumers (2.7^a), followed by white chocolate (2.4^{a,b}) and milk chocolate (2.1^b).

The same procedure was used to find significant difference in the emotional profiles given by consumers with different user frequency. All the respondents were divided in three groups: high user, medium user and low user. The high users are the respondents that indicate to eat chocolate at least once a week. The medium users are those who eat chocolate at least once a month but not every week. The low users are those consumers who indicate to eat chocolate less than once a month. This grouping divided the respondents proportionally.

For the mint chocolates, no significant differences were found among the emotional profiles given by the different users. Again for two emotions, differences are found among the three groups of users. Low (1.9^a) and medium (1.9^a) users found the orange chocolate more '*disgusting*' than high chocolate users (1.4^b). High (2.7^a) and medium (2.6^a) felt more '*energetic*' when tasting the orange chocolate than the low (2.1^b) chocolate users.

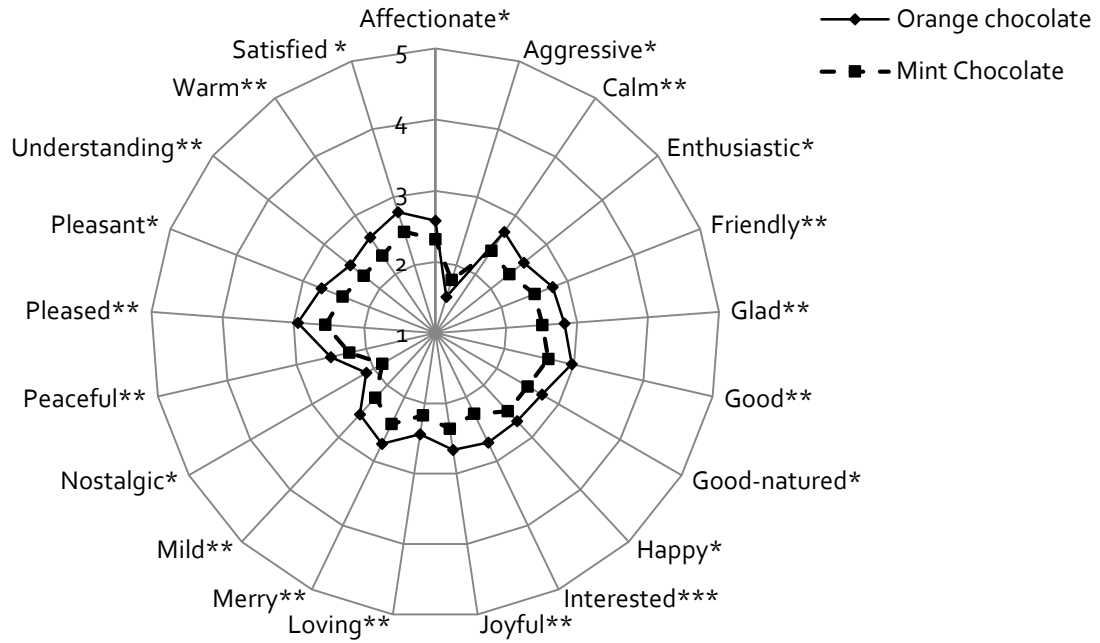


Figure 5. 4: Mean emotional responses given by male respondents to the orange and mint flavoured chocolate. Significant difference is indicated: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$

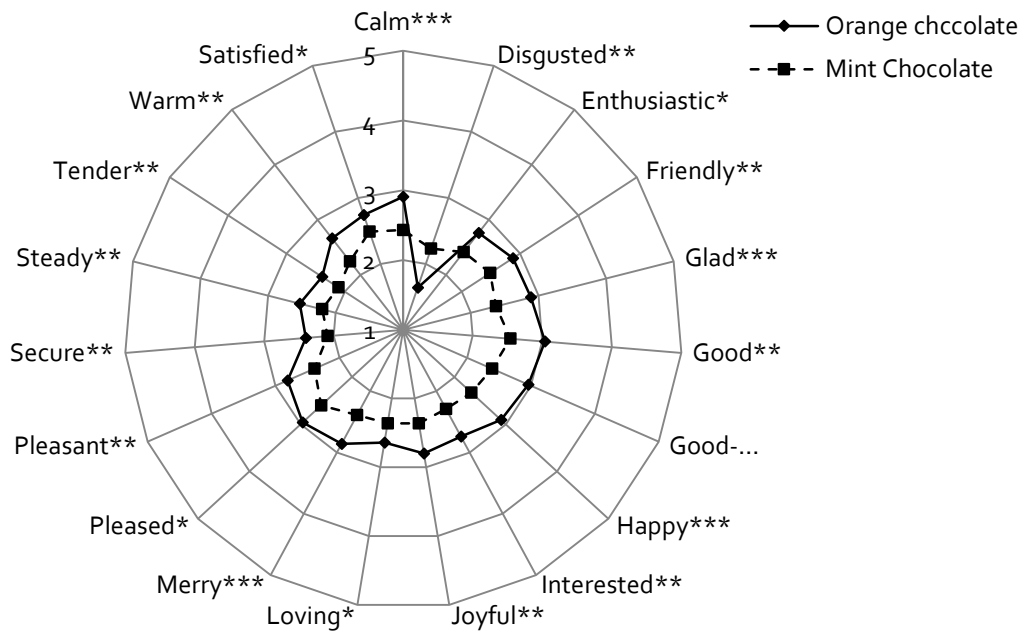


Figure 5. 5: Mean emotional responses given by female respondents to the orange and mint flavoured chocolate. Significant difference is indicated: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$

5.3.3. Experiment 3

5.3.3.1. *Different flavours result in different emotional profiles*

Overall liking scores

A paired samples t-test was carried out on liking scores of the consumers that tasted the 2 chocolate samples (n=715). Significant differences were found in consumers' overall liking for the products ($p < 0.001$). The raspberry flavoured chocolate was found to be the least liked (6.47) while natural dark chocolate was most liked product (7.00).

Emotional profiles

The mean emotional responses to chocolate name, raspberry flavoured chocolate and dark chocolate show a significant difference for only one of the 24 emotion terms.

The emotional profile shows that for eleven positive emotions, the mean score stands out. These eleven emotions are 'calm', 'glad', 'desire', 'good-natured', 'eager', 'happy', 'satisfied', 'energetic', 'enthusiastic', 'pleasant' and 'affectionate'. This indicates that the respondents only feel positive emotions towards the chocolate name, raspberry flavoured chocolate and dark chocolate.

Correlations were calculated between the liking ratings for the two (raspberry flavoured and dark) chocolates and each of the 24 emotion word ratings (Table 5. 4). As can be seen, emotions with positive valence were positively correlated to liking whereas the emotions with negative valence such as 'angry', 'disgusted' for the raspberry flavoured chocolate and 'shame', 'sad', 'unattractive', 'uncontrolled', 'tensed', 'disgusted' for dark chocolates were negatively correlated to liking.

5.3.3.2. *Influence of gender*

A two-way ANOVA (with Tukey's test) was performed on the emotion ratings considering treatment (tasting and non-tasting), gender and their interaction as explanatory variables to examine their effect on the emotion ratings. The results of the two-way ANOVA (considering the treatment, gender and their interaction as explanatory variables) highlighted which of these emotion scores was significantly different. This was mainly depending mainly on gender (*guilty*, $p < 0.001$; *shame*, $p < 0.001$; *glad*, $p < 0.05$; *sad*, $p < 0.05$; *uncontrolled*, $p < 0.01$; *tensed*, $p < 0.05$; *enthusiastic*, $p < 0.01$; *pleasant*, $p < 0.01$), on the treatment (*good-natured*, $p < 0.05$) and on the interaction between the treatment and gender (*scared*, $p < 0.01$; *aggressive*, $p < 0.05$; *worried*, $p < 0.01$; *nostalgic*, $p < 0.05$; *pleasant*, $p < 0.05$; *affectionate*, $p < 0.05$). These results seem to indicate that the emotions ratings reported for chocolate name and chocolate tasting are gender-dependent.

When looking at the emotional profiles given by the men for the chocolate name and the two types of chocolate, significant differences are found for 'good-natured' ($p < 0.05$) and 'worried' ($p < 0.01$). Dark chocolate received a higher mean score for 'good-natured' and a lower mean score for 'worried'. The emotional profiles that women gave to chocolate name and the two

types of chocolates is significantly different for 5 emotions (*scared*, $p < 0.05$; *eager*, $p < 0.05$; *satisfied*, $p < 0.05$; *nostalgic*, $p < 0.05$; *pleasant*, $p < 0.05$). For these five emotions, dark chocolate received the highest mean score whereas chocolate name received the lowest mean score for '*scared*', '*eager*', '*nostalgic*' and '*pleasant*' and the raspberry flavoured chocolate had the lowest mean score for '*satisfied*'.

Table 5. 4: Significant correlation coefficients (Pearson r) between emotion and liking ratings for both chocolates (raspberry and dark chocolate)

	Raspberry	Dark
Angry	-0.117*	-0.075
Scared/Afraid	-0.031	0.004
Guilty	-0.049	-0.078
Shame	-0.046	-0.145**
Calm	0.211***	0.215***
Glad	0.237***	0.248***
Desire	0.115*	0.226***
Good-natured	0.205***	0.182***
Aggressive	-0.038	-0.058
Worried	-0.071	0.024
Sad	-0.040	-0.088*
Unattractive	-0.042	-0.099*
Eager	0.099*	0.168**
Happy	0.141**	0.189***
Satisfied	0.159**	0.177***
Nostalgic	0.134**	0.076
Uncontrolled	-0.032	-0.097*
Tensed	-0.042	-0.093*
Disgusted	-0.252***	-0.128*
Energetic	0.083	0.169**
Enthusiastic	0.184***	0.179***
Pleasant	0.200***	0.171**
Affectionate	0.190***	0.233***
Depressed	0.029	-0.051

Significant difference is indicated: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$

Within each treatment (chocolate name, raspberry flavoured chocolate and dark chocolate), the differences between men and women is studied. The most significant differences (nine emotions) between the genders is found for the chocolate name, whereas for raspberry flavoured and dark chocolate only three significant differences between the genders is found. Men give a significantly higher emotion rating on chocolate name for '*scared*', '*guilty*', '*shame*', '*sad*', '*happy*', '*nostalgic*', '*uncontrolled*', '*enthusiastic*' and '*pleasant*'. When tasting dark chocolate, women give a significantly higher rating to '*scared*' and '*worried*' whereas men give a higher score for '*guilty*'. For tasting raspberry flavoured chocolate, women gave a significantly higher rating for '*aggressive*' and men a higher rating for '*guilty*' and '*worried*'.

5.3.3.3. Difference due to user frequency or preference

A user profile (low, medium or high) was given to each respondent based on the question for user frequency. Respondents who indicated to eat chocolate more than once a week were classified as a high user. Those who eat chocolate once a week or more than once a month received the label of medium user and those who eat chocolate less than once a month are indicated to be low chocolate users (similar to experiment 2).

A two-way ANOVA was again conducted to examine the effect of the treatment, user profile and interaction between treatment and user profile on the intensity ratings for emotions. There was no statistically significant interaction between treatment and user frequency. Moreover, no simple main effects for treatment were found either. Simple main effects analysis showed differences for user frequency for 'calm' ($p < 0.01$), 'glad' ($p < 0.001$), 'desire' ($p < 0.001$), 'good-natured' ($p < 0.001$), 'eager' ($p < 0.001$), 'happy' ($p < 0.001$), 'satisfied' ($p < 0.001$), 'nostalgic' ($p < 0.01$), 'energetic' ($p < 0.001$), 'enthusiastic' ($p < 0.001$), 'pleasant' ($p < 0.001$) and 'affectionate' ($p < 0.001$).

Since no interaction effect was found, an ANOVA was conducted for each treatment to find differences for the user frequency. Table 5. 5 shows that high users give significantly higher emotion scores than medium and low users. Further, the results also indicate that significant differences are observed solely for positive emotions.

Table 5. 5: Mean values on emotions depending on the treatment (chocolate name, dark chocolate or raspberry flavoured chocolate) and user frequency (low, medium or high).

	Chocolate name			Dark chocolate			Raspberry flavoured chocolate		
	low	medium	high	low	medium	high	low	medium	high
Calm	2.4 ^b	2.9 ^{a,b}	3.0 ^a	-	-	-	-	-	-
Glad	3.1 ^b	3.5 ^{a,b}	3.7 ^a	3.0 ^b	3.3 ^{a,b}	3.6 ^a	-	-	-
Desire	2.5 ^b	2.8 ^{a,b}	3.1 ^a	2.5 ^b	2.9 ^{a,b}	3.2 ^a	2.5 ^b	2.8 ^{a,b}	3.1 ^a
Good-natured	-	-	-	2.7 ^b	3.1 ^a	3.3 ^a	-	-	-
Eager	2.1 ^b	2.3 ^{a,b}	2.7 ^a	2.3 ^b	2.5 ^{a,b}	2.9 ^a	2.2 ^b	2.6 ^{a,b}	2.7 ^a
Happy	2.9 ^b	3.3 ^{a,b}	3.7 ^a	2.9 ^b	3.3 ^a	3.7 ^a	2.9 ^b	3.4 ^a	3.4 ^a
Satisfied	-	-	-	2.6 ^b	3.1 ^a	3.4 ^a	2.6 ^b	3.1 ^a	3.2 ^a
Energetic	2.6 ^b	2.7 ^b	3.3 ^a	2.7 ^b	3.0 ^{a,b}	3.2 ^a	2.6 ^b	2.8 ^{a,b}	3.2 ^a
Enthusiastic	2.7 ^b	3.0 ^{a,b}	3.3 ^a	2.9 ^b	3.1 ^{a,b}	3.4 ^a	2.6 ^b	3.1 ^a	3.2 ^a
Pleasant	2.2 ^b	2.6 ^{a,b}	3.0 ^a	2.5 ^b	2.8 ^{a,b}	3.1 ^a	2.3 ^b	2.9 ^a	3.0 ^a
Affectionate	-	-	-	2.5 ^b	2.8 ^{a,b}	3.2 ^a	2.6 ^b	2.8 ^{a,b}	3.1 ^a

Only mean values for significantly different emotions are presented.

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

Another two-way ANOVA was performed with the factors treatment and preference for white, milk or dark chocolate and the interaction between treatment and preference (Table 5. 6). No significant difference was found for the interaction terms. The results of the two-way ANOVA did however showed simple main effects for treatment (*good-natured*, $p<0.05$; *tensed*, $p<0.05$; *disgusted*, $p<0.05$) and preference (*shame*, $p<0.05$; *calm*, $p<0.05$; *glad*, $p<0.01$; *desire*, $p<0.01$; *good-natured*, $p<0.05$; *unattractive*, $p<0.01$; *happy*, $p<0.01$; *satisfied*, $p<0.05$; *nostalgic*, $p<0.05$; *uncontrolled*, $p<0.05$; *disgusted*, $p<0.01$; *energetic*, $p<0.05$; *enthusiastic*, $p<0.05$; *pleasant*, $p<0.01$; *affectionate*, $p<0.01$).

The results show that respondents who prefer dark chocolate give a higher emotion rating for 'glad' and 'eager' when they need to rate the emotions based on the wording 'chocolate' (Table 5. 6). Respondents who prefer milk chocolate give a higher rating for all the significantly different emotions when tasting dark chocolate. Three emotions are positive ('glad', 'desire' and 'happy') and for these emotions, the dark chocolate lovers give a significantly higher score than the white chocolate lovers. For the raspberry flavoured chocolate, only three emotions are significantly different namely 'happy', 'disgusted' and 'depressed'. For the positive emotion 'happy', the respondents who prefer dark chocolate give the highest score whereas for the negative emotions 'disgusted' and 'depressed' the highest score is given by the respondents with a preference for white chocolate.

Table 5. 6: Mean values on emotions depending on the treatment (chocolate name, dark chocolate or raspberry flavoured chocolate) and preference (white, milk or dark chocolate).

	Chocolate name			Dark chocolate			Raspberry flavoured chocolate		
	white	milk	dark	white	milk	dark	white	milk	dark
Shame	-	-	-	1.2 ^{a,b}	1.3 ^a	1.20 ^b	-	-	-
Glad	3.00	3.1 ^{a,b}	3.7 ^a	3.0 ^b	3.5 ^a	3.5 ^a	-	-	-
Desire	-	-	-	2.4 ^b	2.9 ^a	3.2 ^a	-	-	-
Unattractive	-	-	-	1.2 ^{a,b}	1.4 ^a	1.2 ^b	-	-	-
Eager	1.9 ^b	2.4 ^{a,b}	2.7 ^a	-	-	-	-	-	-
Happy	-	-	-	3.0 ^b	3.6 ^a	3.5 ^a	3.0 ^b	3.4 ^{a,b}	3.4 ^a
Uncontrolled	-	-	-	1.7 ^b	1.9 ^a	1.6 ^b	-	-	-
Tensed	-	-	-	1.0 ^b	1.3 ^a	1.1 ^{a,b}	-	-	-
Disgusted	-	-	-	-	-	-	1.3 ^a	1.2 ^{a,b}	1.0 ^b
Depressed	-	-	-	-	-	-	1.2 ^a	1.2 ^a	1.1 ^b

Only mean values for significantly different emotions are presented.

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

5.3.3.4. Effect of attitude to chocolate on the emotion response

The exploratory factor analysis yielded a two factor solution (Table 5. 7) explaining a total of 46.2% of the variance in the original data. This explained variance is similar to previous

studies (Benton et al., 1998, Müller et al., 2008, Cramer and Hartleib, 2001) and can therefore be accepted for further analysis. Six items were deleted as the factor loadings indicated that they did not fit to one of the two factors ('I consider chocolate as high in fat', 'I only eat chocolate when I'm hungry', 'I look at the caloric value before I eat chocolate', 'I have a feeling of control after not eating chocolate', 'I carry on eating chocolate even when I don't want to' and 'I eat chocolate to keep my energy levels up'). On the first factor high loadings were related to items that are associated with a desire or craving to eat chocolate or another positive attitude towards chocolate. This first factor is called the '*craving*' factor. The second factor included more negative attitudes towards chocolate and is called in literature, the '*guilt*' factor (Benton et al., 1998, Müller et al., 2008). The internal reliability for these two factors was checked and high Cronbach's alpha was found for both factors (Table 5. 7).

Table 5. 7: Output of the exploratory values of the final items in the factor analysis on the ACQ. Only factor loadings above 0.20 are presented for the two factor solution

	Craving	Guilt
	Cronbach's α = 0.851	Cronbach's α = 0.823
Chocolate preys on my mind	0.752	
My desire to eat chocolate is overpowering	0.744	
I eat chocolate to cheer me up	0.700	
I want chocolate during the afternoon	0.679	
I often end up buying chocolate	0.659	
Only chocolate satisfies my craving	0.639	
I eat chocolate as a reward	0.571	0.314
The thought of chocolate distracts me	0.570	0.311
I like to indulge in chocolate	0.563	-0.203
I eat chocolate when I'm bored	0.504	0.374
I eat more chocolate in the winter	0.455	
I feel unattractive after I eating chocolate		0.818
I feel guilty after eating chocolate		0.816
I regret eating chocolate		0.735
I feel unhealthy after eating chocolate		0.728
I feel sick after eating chocolate		0.692
I feel dissatisfied after eating chocolate		0.525
I am often on a diet		0.507

A hierarchical clustering followed by a K-means cluster analysis was used to determine the optimal number of clusters. This resulted in a three-cluster solution (Table 5. 8). The first cluster was comprised of respondents that had a high craving feeling and low in guilt. This cluster was called the '*craving*' consumers. The respondents in the second cluster scored high in both craving and guilt factor and this clusters is therefore called the '*emotional*' eaters. The last cluster contained respondents with a low score for both '*craving*' and '*guilt*' and is

therefore called the 'non-emotional' eaters. Cluster 1 contained 370 respondents, the second 217 respondents and the third cluster 323 respondents.

Table 5. 8: Final cluster centres after clustering on the factors scores of the ACO

	Craving consumers	Emotional eaters	Non-emotional eaters
Craving	4.39	4.40	2.63
Guilt	1.86	3.72	1.71

After defining these clusters, a similar two-way ANOVA was conducted on the emotion ratings considering treatment (tasting and non-tasting), clusters and their interaction as explanatory variables to examine their effect on the emotion ratings. Significant differences were found for the interaction term on four emotions (*worried*, $p < 0.01$; *enthusiastic*, $p < 0.05$; *pleasant*, $p < 0.05$; *affectionate*, $p < 0.05$) and two simple main effects were found for the treatment (*good-natured*, $p < 0.05$; *tensed*, $p < 0.05$). For all the 24 emotions, significant differences were found among the clusters (Table 5. 9).

Table 5. 9: Mean values on emotions for the three cluster (craving, emotional or non-emotional).

	Craving	Emotional	Non emotional	- F (2,901)	Sign
Angry	1.1 ^b	1.3 ^a	1.1 ^b	18.163	<0.001
Scared/Afraid	1.1 ^b	1.2 ^a	1.1 ^b	5.049	0.007
Guilty	1.5 ^b	2.5 ^a	1.3 ^c	151.187	<0.001
Shame	1.2 ^b	1.6 ^a	1.1 ^b	56.807	<0.001
Calm	3.3 ^a	2.9 ^b	2.7 ^b	20.886	<0.001
Glad	3.9 ^a	3.6 ^b	3.1 ^c	41.079	<0.001
Desire	3.3 ^a	3.2 ^a	2.5 ^b	39.149	<0.001
Good-natured	3.3 ^a	3.0 ^b	2.7 ^c	24.388	<0.001
Aggressive	1.1 ^b	1.2 ^a	1.1 ^b	4.849	<0.001
Worried	1.3 ^b	1.6 ^a	1.1 ^c	36.640	<0.001
Sad	1.1 ^b	1.5 ^a	1.1 ^b	29.411	<0.001
Unattractive	1.2 ^b	1.6 ^a	1.2 ^b	22.322	<0.001
Eager	2.9 ^a	3.1 ^a	2.0 ^b	66.226	<0.001
Happy	3.8 ^a	3.5 ^b	2.9 ^c	63.119	<0.001
Satisfied	3.5 ^a	3.2 ^b	2.8 ^c	29.176	<0.001
Nostalgic	2.3 ^a	2.2 ^a	1.7 ^b	21.039	<0.001
Uncontrolled	1.7 ^b	2.5 ^a	1.3 ^c	86.802	<0.001
Tensed	1.2 ^b	1.5 ^a	1.1 ^b	26.803	<0.001
Disgusted	1.1 ^b	1.3 ^a	1.1 ^b	14.500	<0.001
Energetic	3.4 ^a	3.0 ^b	2.7 ^c	37.580	<0.001
Enthusiastic	3.6 ^a	3.1 ^b	2.7 ^c	50.270	<0.001
Pleasant	3.2 ^a	2.8 ^b	2.5 ^c	31.753	<0.001
Affectionate	3.3 ^a	2.8 ^b	2.5 ^c	37.098	<0.001
Depressed	1.1 ^b	1.5 ^a	1.1 ^b	46.983	<0.001

Only mean values for significantly different emotions are presented (Post-hoc test (Tukey) results)

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

The results indicated that for all the emotions, the respondents grouped in cluster 3 (non-emotional) gave the lowest emotion ratings. The cluster '*craving*' gave the highest score for nine emotions ('*calm*', '*glad*', '*good-natured*', '*happy*', '*satisfied*', '*energetic*', '*enthusiastic*', '*pleasant*' '*affectionate*') which are indicated as positive emotions. Therefore, respondents that crave for chocolate associate this craving with positive emotions.

The cluster '*emotional*' gave the highest score for twelve emotions ('*angry*', '*scared*', '*guilty*', '*shame*', '*aggressive*', '*worried*', '*sad*', '*unattractive*', '*uncontrolled*', '*tensed*', '*disgusted*', '*depressed*') which are indicated as negative emotions. These results clearly indicated that emotional eaters, who indicated to have a high craving and guilt feeling, associates chocolate with negative feeling. There are three emotions for which the mean score for cluster '*craving*' and cluster '*emotional*' are not significantly different from each other but significantly higher than for the cluster '*non-emotional*' namely '*desire*', '*eager*' and '*nostalgic*'. The first two emotions can have a positive or negative meaning whereas nostalgic is indicated to be a positive emotion.

In accordance to the previous analyses, an ANOVA test was conducted for the three treatments (Table 5. 10). Similar results are found as for the simple main effects. The group respondents in the '*non-emotional*' clusters give the lowest scores for all the emotions in the three treatments. None of the negative emotions receives the highest score from the '*craving*' cluster.

One-way ANOVA for every cluster with the treatment as factor indicated the significant differences for the emotional ratings. For the respondents in cluster '*craving*', a significant difference was found for '*shame*' ($p < 0.01$) and '*good-natured*' ($p < 0.01$). The respondents who did not taste chocolate indicated to have a higher feeling of '*shame*'. Therefore, it can be suggested that the feeling of shame decreases when these persons' craving is satisfied. The persons who tasted dark chocolate gave a higher value for '*good-natured*'. This confirms their overall more positive feeling when eating chocolate.

The results for the cluster '*emotional*' showed only one significant difference namely '*worried*' ($p < 0.05$). The respondents who did not taste chocolate felt more worried than those who needed to taste chocolate during the experiment. However, it must be taken into account that the interaction term for treatment and cluster was significantly different for '*worried*'.

In the cluster '*non-emotional*' significant differences were found for '*happy*' ($p < 0.05$), '*uncontrolled*' ($p < 0.05$), '*enthusiastic*' ($p < 0.05$). '*Happy*' showed a significant difference among the persons who did not taste chocolate (3.1) and those who tasted raspberry flavoured chocolate (2.7). This could indicate that these person did not appreciate the taste of this flavoured chocolate. The feeling of '*uncontrolled*' was highest for the group that taste dark chocolate (1.4), and lowest for the group that did not taste chocolate (1.2). The third significant difference was found for the emotion '*enthusiastic*' which was highest for the respondents that did not taste chocolate (2.9) and lowest for those who tasted raspberry flavoured chocolate (2.5). However, for this last emotion, the significant differences found for

the interaction term for treatment and cluster must be considered when discussing the results.

Table 5. 10: Mean values on emotions depending on the treatment (chocolate name, dark chocolate or raspberry flavoured chocolate) and cluster (craving, emotional or non-emotional).

Treatment	Chocolate name			Dark chocolate			Raspberry flavoured chocolate		
Cluster	craving	emotional	non-emotional	craving	emotional	non-emotional	craving	Emotional	non-emotional
Angry	1.1 ^b	1.5 ^a	1.0 ^b	-	-	-	1.1 ^b	1.3 ^a	1.1 ^b
Scared/Afraid	-	-	-	-	-	-	1.1 ^b	1.2 ^a	1.0 ^b
Guilty	1.5 ^b	2.7 ^a	1.4 ^b	1.5 ^b	2.4 ^a	1.4 ^b	1.5 ^b	2.6 ^a	1.2 ^c
Shame	1.3 ^b	1.7 ^a	1.1 ^b	1.1 ^b	1.6 ^a	1.1 ^b	1.1 ^b	1.5 ^a	1.1 ^b
Calm	3.1 ^a	2.7 ^b	2.7 ^b	3.4 ^a	3.0 ^b	2.7 ^b	3.2 ^a	2.9 ^{a,b}	2.6 ^b
Glad	3.8 ^a	3.5 ^{a,b}	3.3 ^b	3.9 ^a	3.5 ^b	3.0 ^c	3.8 ^a	3.7 ^a	3.0 ^b
Desire	3.2 ^a	3.1 ^{a,b}	2.6 ^b	3.3 ^a	3.2 ^a	2.5 ^b	3.3 ^a	3.2 ^a	2.3 ^b
Good-natured	3.1 ^a	2.8 ^{a,b}	2.6 ^b	3.5 ^a	3.2 ^b	2.7 ^c	3.2 ^a	3.0 ^a	2.6 ^b
Aggressive	-	-	-	1.0 ^b	1.2 ^a	1.1 ^{a,b}	-	-	-
Worried	1.3 ^b	1.9 ^a	1.0 ^c	1.3 ^{a,b}	1.4 ^a	1.2 ^b	1.3 ^b	1.6 ^a	1.1 ^b
Sad	1.2 ^b	1.6 ^a	1.0 ^b	1.1 ^b	1.4 ^a	1.1 ^b	1.1 ^b	1.4 ^a	1.1 ^b
Unattractive	1.2 ^b	1.6 ^a	1.1 ^b	1.2 ^b	1.7 ^a	1.2 ^b	1.3 ^{a,b}	1.6 ^a	1.2 ^b
Eager	2.8 ^a	2.9 ^a	2.0 ^b	3.0 ^a	3.1 ^a	2.1 ^b	2.9 ^a	3.1 ^a	1.8 ^b
Happy	3.8 ^a	3.4 ^b	3.1 ^b	3.8 ^a	3.5 ^b	3.0 ^c	3.8 ^a	3.5 ^a	2.7 ^b
Satisfied	3.5 ^a	3.3 ^{a,b}	2.9 ^b	3.5 ^a	3.1 ^b	3.0 ^b	3.3 ^a	3.2 ^a	2.6 ^b
Nostalgic	2.3 ^a	2.8 ^{a,b}	1.8 ^b	2.3 ^a	2.3 ^a	1.8 ^b	2.3 ^a	2.3 ^a	1.6 ^b
Uncontrolled	1.6 ^b	2.7 ^a	1.2 ^b	1.7 ^b	2.4 ^a	1.4 ^b	1.7 ^b	2.4 ^a	1.3 ^c
Tensed	1.2 ^b	1.6 ^a	1.1 ^b	1.2 ^{a,b}	1.3 ^a	1.1 ^b	1.2 ^b	1.6 ^a	1.1 ^b
Disgusted	-	-	-	1.0 ^b	1.3 ^a	1.1 ^b	1.1 ^b	1.3 ^a	1.1 ^b
Energetic	3.4 ^a	2.8 ^b	2.7 ^b	3.4 ^a	2.9 ^b	2.7 ^b	3.4 ^a	3.1 ^a	2.5 ^b
Enthusiastic	3.6 ^a	2.9 ^b	2.9 ^b	3.5 ^a	3.3 ^a	2.8 ^b	3.6 ^a	3.1 ^b	2.5 ^c
Pleasant	3.0 ^a	2.5 ^b	2.7 ^{a,b}	3.3 ^a	2.9 ^b	2.5 ^c	3.3 ^a	2.9 ^a	2.3 ^b
Affectionate	3.2 ^a	2.6 ^b	2.7 ^b	3.4 ^a	2.8 ^b	2.6 ^b	3.3 ^a	3.0 ^a	2.3 ^b
Depressed	1.1 ^b	1.6 ^a	1.0 ^b	1.1 ^b	1.5 ^a	1.1 ^b	1.1 ^b	1.4 ^a	1.1 ^b

Only mean values for significantly different emotions are presented

^{abc} Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey's HSD test.

5.4. Discussion

5.4.1. Sensory profiles evoke different emotional profiles and affective ratings

In the first experiment, the frequency of selecting across all emotions ranged from 0 to 61 in which negative emotions obtained lower frequencies compared to positive emotions. This supports the findings of other authors who observed that a majority of emotional self-reports on food in published literature are positive since eating is basically a positive experience and the point that actual food products are meant to please the consumers (Gibson, 2006, Desmet and Schifferstein, 2008).

PB was positioned with mainly positive emotions as '*joyful*', '*happy*', '*merry*', '*warm*' and '*adventurous*'. PLB was associated with positive emotions such as '*pleasant*', '*good-natured*', '*active*', '*steady*' and '*whole*' while TB was related to some negative feelings as '*bored*' and '*disgusted*' but also associated with some positive emotions such as '*calm*', '*tender*' and '*friendly*'.

It is particularly interesting to note that TB obtained significantly higher '*nostalgic*' emotion frequency count (18) compared with the other samples (7) although it was unbranded. Personal interviews after the consumer test with the respondents who checked this emotion, revealed that during the tasting of the sample, they are reminded of their childhood and they associate the taste with that period in their lives. It is a brand of chocolate that is often given by grandparents to their grandchildren and it is a traditional or old brand of chocolate that they were fond of during their childhood. This confirms findings from Braun, Ellis, and Loftus (2002) that showed that early childhood brand relationships are the emotional basis for later adult brand relationships. Although majority of the respondents (92%) were students and relatively young (18-25 years old), they felt the nostalgia of consuming TB. Bambauer-Sachse & Gierl (2009) in their study on nostalgia in advertising intentionally used a sample consisting of people of different age groups in one study (mean age = 45 years) and a student sample in the other study (mean age = 25 years) to prove that the results hold across age groups and they concluded that positive effects of nostalgic advertising do not necessarily depend on the age of the advertising recipients.

The result of the acceptance test showed that the consumers are somewhat divided in terms of their liking of TB. The '*nostalgic*' emotion helps to explain why some respondents gave a higher acceptance score for TB since nostalgia is a part of people's consumption experience and therefore a part of preference or choice (Goulding, 2001). This shows that the milk chocolates with different sensory characteristics have different emotional profiles.

Partial Least Square Regression of the emotional and overall liking data indicated that liking is associated with specific emotions. If a product scores well along these emotions, overall liking for this specific product will increase. This explains the significantly higher overall

acceptance of PB compared to the other samples. Therefore, it can be concluded that the emotional profiles of the chocolates have an influence on the acceptance of the samples. Although Afoakwa (2010) and Dürschmid et al. (2006) indicated that chocolate texture influences the sensory assessment therefore it would be interesting to study if sensory differences influence the emotional profile of chocolates. Although the texture of the used products in the first experiment, this could not be concluded as differences were found for other sensory characteristics of these chocolates.

5.4.2. Different chocolate flavours produce different emotions and levels of emotions.

Several studies stated already that chocolate is a more emotional food than other food products (Cardello et al., 2012, Macht and Dettmer, 2006, Thompson et al., 1994). The second experiment showed that emotional profiles of mint and orange chocolate differed for 25 out of the 38 emotions whereas in experiment 3 only one emotion was significantly different among the treatment (chocolate name, raspberry flavour and dark chocolate). The absence of differences among the two flavoured chocolates from experiment 3 is in accordance to the study of Cardello et al. (2012) who did not find significant differences in the emotional profile for the same product with different flavours. The difference between experiment 2 and 3 can be explained if it is presumed that emotions related to flavour can be triggered by three factors namely type of flavour, concentration of flavour and time of exposure to flavour. Supposed that the latter is identical for both samples, the impact of concentration is not accounted for. As these were commercial samples and the concentrations were therefore unknown, this could influence the results of these experiments. Further research studies must be conducted in which the samples are prepared with identical odour activity value.

Previous studies showed that food names and tasting food products elicits an emotional response in consumers. In this experiment, the term 'chocolate' and tasting chocolates with different flavours was used as a treatment factor to find differences in this emotional response.

Further no differences were found for the obtained emotional profiles when presented with the name 'chocolate' or presented with the chocolate used in this experiment. This result contradicts with the results found by Cardello et al. (2012) whose study showed differences between tasting foods and corresponding food names. However, as stated in the article as well, the conditions of the experiment with food names were different than the test with food tasting. The first was conducted in a conference room and the latter in sensory test booths. The laboratory environment might have had an effect on the magnitude rating of the emotions and therefore caused significant differences in the emotional profiles (Köster and Mojet, 2015). Within this experiment, the environment was identical and prone to evoke emotions (an open-air fair). The environment was also closer to a real situation in which chocolates are consumed than the lab environment. Piqueras-Fizman and Jaeger (2014a, 2014b) have demonstrated the context effect and how important it is to set up the environment of the

design or let consumers think of an appropriate situation in which they would consume the studied food product, while evaluating the food product.

The results of correlations correspond to the idea that food products are designed to evoke positive emotions and thus attract consumers to buy and eat the product which was already stated by the study of Cardello (2012). Moreover, the hedonic asymmetry of commercial products as explained by Desmet and Schifferstein (2008) is also confirmed in this paper. The results show that the magnitude of the positive emotions for chocolate is higher than for the negative emotions.

5.4.3. Difference in emotional profiles due to gender

The first experiment showed that acceptability for each type of chocolate was not influenced by gender. Gutjar et al. (2015) also reported no gender influence in their study on breakfast drinks, although they mentioned their respondents unintentionally consisted of three times more women than men.

The second experiment showed no significant difference for the used samples among men and women whereas the third experiment showed three significant differences in emotions for dark and raspberry chocolate. This corresponds to the findings of Gutjar et al. (2015) where no differences between both genders were found when evaluating breakfast drinks whereas Jaeger and Hedderley (2013) did find a gender effect although they indicated that previous research states that gender differences are absent in basic emotional processes (Damasio, 2001, Robin et al., 2003). Further, when the respondents did not taste the chocolate and rated their emotions for the term 'chocolate' and thus only thought of chocolate, significant differences were detected. Cardello et al. (2012) also found differences in emotional response to food names and food tasting. More striking was that men gave higher emotion ratings than woman.

The results for the emotional profile given by the males in the second experiment showed that based on the flavour differences present in the selected samples, emotional differences are found. This was confirmed, although with only two significant different emotions, in the third experiment. Similar results were found for the female respondents. The flavours at their respective concentrations thus stimulate different emotions in males and females although these differences are not significantly different among the genders.

5.4.4. Effect of preference or user frequency

The past behaviour or habit of a consumer can have an effect on the emotions of the consumer towards a product. Therefore the influence of initial preference on the emotional profiling is analysed. The first experiment indicated that acceptability for each type of chocolate was not influenced by the type of chocolate that respondents prefer (dark, milk or white). Further, the second experiment showed little effect for the mint chocolates and no influence for the orange chocolate. In the third experiment, the interaction term for the treatment and preference in the two-way ANOVA gave no significant differences whereas

the simple main effect for preference showed significant differences for 15 emotion terms. Further analysis conducted for the three treatments clarified these differences. When tasting chocolate, the respondents who prefer milk chocolate gave a higher value for the emotions that were significantly different. For the chocolate name, only two significant differences were found for which dark chocolate lovers gave the highest value for these emotions.

Similar analysis was performed for the user frequency as previous experiences also influence the emotions towards a food product. The second experiment showed no significant differences for the mint chocolate and only two differences for the orange chocolate. A difference in flavour does not give a significant effect among different types of chocolate consumers. This could indicate that specialty chocolates are not influenced by the respondents' user frequency of the studied product category. The added flavour causes the chocolate to be handled as a specialty product and not as an average piece of chocolate. Plain chocolate is a common product for Belgian consumers that is interrelated with their culinary culture (Garrone et al., 2015). This is in accordance with the results of Jaeger and Hedderley (2013) who found no differences in the EsSense profile® for the different milk chocolate flavours.

The two-way ANOVA of the third experiment indicated that the interaction factor had no influence. The high significant scores given by the high frequency users to chocolate name and when tasting dark chocolate is striking. The more a consumer is familiar with a product, the higher the intensity of the emotions towards this product which confirms the findings from King and Meiselman (2010). Although this contradicts to the results of Jaeger and Hedderley (2013), it can be argued that these authors conducted the analysis with different stimulus presentation during the same experiment. Cardello et al. (2012) already indicated that this could bias the results. Moreover, De Pelsmaecker et al. (2013a) state that familiar brands evoke positive emotions. The results indicate that only positive emotions were significantly different, therefore the same reasoning could state that higher familiarity with the product category due to user frequency, causes higher intensity of positive emotions. Given that familiarity and product exposure lead to acceptability (Gibson, 2006), the results indicate that positive emotions also lead to higher acceptance.

5.4.5. Attitude towards a product leads emotional profiles

An interesting finding regarding the intensity of emotional profiling was that variation in attitudes to chocolate (ACQ) exerted a strong impact on the intensity of emotion rating of both the chocolate name and the tasted chocolate samples. This corresponds to the study of Piqueras-Fiszman and Jaeger (2014b) that showed the impact of the DEBQ questionnaire on emotion ratings of chocolate brownies. Therefore, it can be concluded that individuals who belong to a cluster either 'craving' or 'emotional' or 'non-emotional', all exhibit different emotions towards the product name or the actual tasted product. When presented only with the food name, the results indicated that individuals in the craving cluster gave a more positive emotional profile towards the products. Similar scores are given after tasting the

dark chocolate and the raspberry chocolate. This indicates that eating chocolate does not alter their emotional state towards chocolate. The craving before eating chocolate does not result in negative emotional profile after eating chocolate. For the individuals assigned to the '*emotional*' cluster, the chocolate name evokes significant more negative emotions. This indicates that emotional eaters give a negative connotation to the word chocolate as they associate it with the guilty feeling that they expect to have afterwards (Cartwright and Stritzke, 2008). Although they still have these negative feelings when they eat chocolate, the positive emotions also emerge (Fletcher et al., 2007) which makes it very difficult for these consumers to reject chocolate knowing that they will feel negative (guilty, unattractive, ...) after consumption (Macht and Dettmer, 2006). The third and final clusters consists of the so called '*non-emotional*' chocolate consumers. These individuals do not perceive chocolate as emotional food. There is no significant difference between the emotional profiles for the chocolate name, tasting dark or tasting raspberry flavoured chocolate.

In the original paper that constructed the ACQ questionnaire (Benton et al., 1998), a third factor '*functional*' emerged next to the '*craving*' and '*guilt*' function. This indicates that there is a third group of persons who perceive chocolate as a food product with functional qualities instead of assigning positive or negative emotions to the product (Thomson et al., 2010). This third factor did not emerge from our factor analysis similar as to other recent studies (Müller et al., 2008). This could indicate that this functional items are not sufficient in describing the attitudes of this group of consumers towards chocolate.

5.5. Conclusion

This chapter shows that no significant effects were found in emotional profiles when presented with the name chocolate or tasting chocolate. This clearly contradicts to previous studies of Cardello (2012). It was discussed that this could be due to the environment in which the experiment takes place as suggested by Piqueras–Fizman and Jaeger (2014a, 2014b). This environmental influence could also indicate why there were many significant differences for the two different flavoured chocolates in experiment 2 and almost no significant differences among the flavoured chocolates in experiment 3. In a follow-up study an experiment can be set up which compares tasting and non-tasting in two different environments.

A limitation of this chapter is that in these three experiments, different chocolates were used which makes the extrapolation of the results impossible. However, experiment 2 was conducted to explore the existence of differences in emotional profiles and therefore two samples that were very different in flavour profile were selected. In the third experiment, the idea was to validate these differences with a plain dark chocolate and a flavoured dark chocolate.

The hedonic asymmetry predicted by Desmet and Schifferstein (2008) was confirmed in this paper. This again shows that product developers should know which positive emotions their product evokes and these aspects should be emphasised by marketers when bringing the product to the market. By enhancing these positive emotions, the consumer acceptance and accordingly the willingness to buy can be enhanced as well. However, the relationship between higher positive emotions and willingness to buy should be subject to future research.

Little to no differences were found among the genders when tasting chocolates. Emotions evoked during chocolate consumption are thus not influenced by gender. However, the search for differences within gender and among flavours indicated that flavours stimulate different emotions in males and females.

Further, the name chocolate did present significant differences and gave a higher emotion rating for men than women which was not expected as it contradicts to what was stated by King et al. (2010) that women express their feelings more than men. Therefore, future research should help to set-up a theoretical framework on how gender differences influence emotional profiles of food products.

Preference for a specific type of chocolate resulted in limited differences in emotion profiles. It can thus be concluded that this has little to no effect on consumers. Nonetheless, high frequent users indicated to have more intense positive emotions than medium and low users. Further research on the effect of user frequency on acceptance is necessary for chocolate but also for other food products.

This research clearly showed that attitudes towards chocolate have an effect on the emotional profiling of a product. This agrees with the results from chapter 4 which indicated the relation between attitudes and emotions in chocolate products. Future research should further explore how these attitudes have an effect on acceptance or how these emotions can steer attitudes towards a product. As this chapter focuses on the relation between sensory experience and evoked emotions, this type of consumer sensory tests can be used in the final stage of the Stage-Gate® process. Knowing which emotions your product will evoke, can help to set up a good marketing mix and correctly position your product on market.

Part 3

Taste as a key factor for product development

You 've got to start with the customer experience and work back toward the technology - not the other way around.

You can't just ask customers what they want and then try to give that to them. By the time you get it built, they'll want something new.

- Steve Jobs

Chapter 6

Consumer-driven product development and improvement combined with sensory analysis: a case-study for European filled chocolates

Adapted from:

De Pelsmaecker, S., Gellynck, X., Delbaere, C., De Clercq, N., Dewettinck, K. (2015). Consumer-driven product development and improvement combined with sensory analysis: a case-study for European filled chocolates. *Food Quality and Preference*, 41, 20-29

Abstract

Food producers are constantly searching for ways to improve existing products and to develop new products. Quality Function Deployment (QFD) methodology was designed to help incorporate the consumer's needs into the development and improvement of products. The House of Quality (HOQ) is the first matrix produced when QFD is applied. Although several adaptations to the HOQ have been made to make the method user-friendly for the food industry, very few industry applications can be found in literature.

This paper presents the possibilities and limitations of the HOQ for the improvement of food products based on consumer preferences, processing parameters and sensory attributes. The method is illustrated by a case-study for filled chocolates. Although the results of the case-study provide insights concerning product improvement of filled chocolates, it also reveals limitations for the application and interpretation of HOQ within the food industry. To tackle these problems, a suggestion can be made to include fuzzy set theory when completing the planning matrix, to incorporate chain information in the HOQ, and to establish good communication between departments. With precise and appropriate application of the HOQ, it is possible for a company to produce products with high consumer preference and, thus, a high success rate.

6.1. Introduction

Food companies are constantly searching for ways to innovate and to develop new or improved products to stay competitive (Craig and Hart, 1992). The difficulty within a company, when improvement or development of a process or product is necessary, is the communication between the involved departments. In order to develop new or improved products, collaboration between R&D, the sensory, and the marketing departments is necessary. However, these functional teams are traditionally situated in different parts of the company, often without any communication or coordination among them (Bech et al., 1994). Therefore, the development of a methodological framework that includes the concerns of the R&D, marketing, processing and sensory department can be of use to collaborate and work more efficiently, thereby saving the company time and money (Craig and Hart, 1992).

Theoretically, Quality Function Deployment (QFD) can meet this need when it is used as a structured approach for product improvement instead of in its traditional use for new product development. In order to use QFD for new product development, the amount of data that is required as input for the method is unlikely to be available for a product that is not on the market yet (Simeone and Marotta, 2010). Moreover, Simeone and Marotta (2010) state that it is challenging to obtain the voice of the consumer for non-existing products.

However, QFD is considered to be the most complete and comprehensive method for integrating the goals of many processes and aligning them to the consumer's requirement (Holmen and Kristensen, 1998). On one hand it identifies problems that lower the acceptance of the consumer, while on the other hand it keeps in mind the process parameters and sensory characteristics of food products (van Kleef et al., 2005). Kwong et al. (2007) state that when a company makes an effort towards meeting the customer requirements, development cycles are shortened, internal conflicts minimized and market penetration increases. Moreover, the quality of the product is improved, which results in higher customer satisfaction and higher revenues.

Within a scientific context, QFD has been applied in the development of various food products, such as butter cookies, tomato ketchup, smoked eel, and chocolate cake mix (Park et al., 2012, Bech et al., 1994, Bech et al., 1997, Hofmeister, 1991, Viaene and Januszewska, 1999). Although scientific studies clearly acknowledge that the use of QFD increases the chance of developing successful products, producing higher quality products and decreasing the cost of development time, the method is rarely used within the food industry (Garcia et al., 2007). This might be due to the fact that the implementation and interpretation is more complex than the current literature suggests (Benner et al., 2003b, Costa et al., 2001). In the few cases in which the method is used, most of the relevant information is confidential and unavailable for the general public (Costa et al., 2001).

Recent research has looked at adjusting the QFD method by making it more flexible and applicable for food companies (Bevilacqua et al., 2012). Sharma et al. (2008) indicated in their review that the post-2000 literature and publications helped in the adaptation of QFD to the maturity of user organisations and ever-evolving market conditions. Bevilacqua et al. (2012) presented an innovative fuzzy QFD-based methodology for characterizing customer ratings of food products.

Although QFD and specifically the House of Quality (HOQ), which is the first matrix in this method, are well known to many researchers, it can be helpful to present an overview of both concepts. Therefore, this paper will first briefly review QFD and HOQ. Next the case of European filled chocolates will be used to illustrate how the HOQ can be developed based on consumer, sensory and instrumental data. In this case the problem of fat bloom is presented to demonstrate the specific use of the HOQ. Finally, the bottlenecks of the HOQ, and in a broader perspective QFD, are given and some recommendations are provided for an update or a simplification of the method.

6.2. Theoretical framework

6.2.1. House of Quality: first step in Quality Function Deployment

Quality Function Deployment (QFD) focuses and coordinates skills within an organization, first to design, then to manufacture and market goods that customers want to purchase and will continue to purchase (Hauser and Clausing, 1988). Chan and Wu (2002) defined QFD as *'an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production'*.

Two main QFD implementation methods are defined in the literature (Hauser and Clausing, 1988, Cohen, 1995, Garcia et al., 2007). The first, the generic approach, is known as the 'Akao matrix of matrices' and is the most comprehensive QFD implementation model (Akao, 1990). It comprises a scheme of 30 matrices in which every matrix element is a part of the development process.

The second approach, known as the 'Four-Phase model', is a technique in which the actual product can be described as several characteristics assembled together in the final product (Park et al., 2012). There are two types of activities involved in this QFD method, namely the product's quality deployment and the deployment of the quality function. The first consists of activities needed to convert customer-required quality into product-specific attributes, whereas the second type of activities are those needed to assure that the customer-required quality which is put into the product, are achieved (Costa et al., 2001). In order to define these activities, cascades of matrix-shaped charts are generated (Benner et al., 2003b). This matrix-generating process has been combined in a four-phase approach which consists of four matrices involving product planning, product design, and process planning and process control planning phases. This first matrix is called the HOQ, in which customer requirements are translated into engineering targets (Benner et al., 2003b, Urban and Hauser, 1993, Cohen, 1995). Hauser and Clausing (1988) defined the HOQ as *'a kind of perceptual map that provides the means for interfunctional planning and communication'* (Figure 6. 1). This research only focuses on this first matrix of QFD, the HOQ.

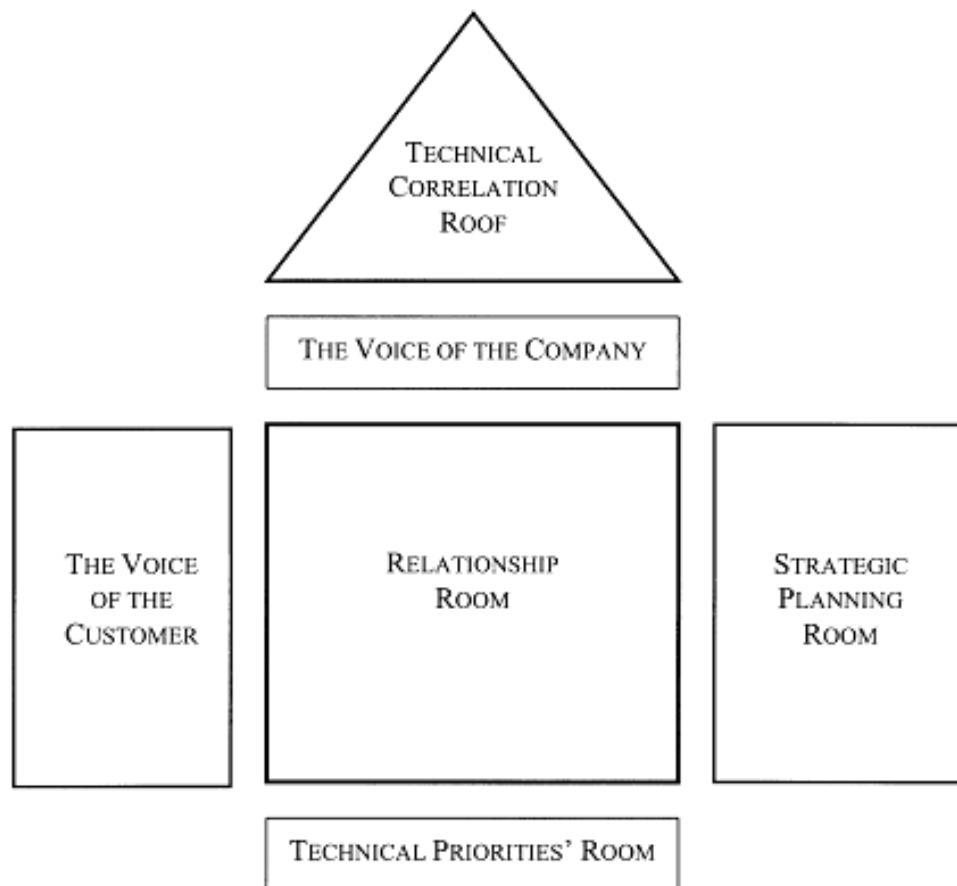


Figure 6. 1: The House of Quality (Costa et al., 2001)

6.2.2. House of Quality and application in the food industry

HOQ has been the main focus in QFD-related literature, because it contains the most critical information a company needs regarding its relationships with customers and its competitive position in the marketplace (Akao and Mazur, 2003). Input for the HOQ needs to be provided by marketing people and food technologists (Linnemann et al., 2006). Within the HOQ, the marketing part, known as 'voice of the customer', tells us what to do, and the technology part, the room of the HOWs, tells us how to do it (Hauser and Clausing, 1988). The link between these departments is crucial to ensure that the company understands customer needs and translates them in an effective way (Gustafsson, 1997). The 'customer' in the QFD method can be a consumer, another manufacturer, a retailer, etc. (Costa et al., 2001). Due to the interlinks between the different departments, it is very complex to apply the HOQ in a company environment. Moreover, it is difficult to determine which department should be in charge of the construction and implementation.

The construction of the HOQ starts with the *identification of customer requirements*, which are called the customer attributes (CA's), as input for the 'voice of the customer' (Hauser and Clausing, 1988). As this paper combines the QFD method with sensory analyses, the consumer is the customer here. Therefore, the consumer needs were determined, clarified,

specified and used as CA's. These attributes can be derived through focus groups, qualitative interviews, or other possible sources of consumer data: market research data, sales data, consumer complaints, retailers, etc. As a wide variety of attributes can be gained from these techniques, the CA's are grouped into bundles. It is important that the bundles are named in the consumer's own words (Griffin and Hauser, 1993). When designers try to rephrase these attributes, it is possible that they no longer correspond to the consumer's actual views. This mistake can mislead the development teams and can result in the company tackling problems which a consumer considers as unimportant.

The next step is identifying what must be achieved to satisfy the consumers' wants. Whereas the marketing domain tells us what to do, the engineering domain tells us how to do it. In this step, the product is described in the words of the engineer. A list of *engineering characteristics (ECs)* is placed along the top of the HOQ. These attributes affect one or more of the CA's. It is important that these engineering characteristics describe the product in measurable terms and that they directly affect consumer perceptions (Govers, 1996).

As a following step, *the (strategic) planning matrix* is constructed on the right side of the HOQ. The main purpose of the planning matrix is to compare how well the product meets the consumer requirements, as compared to its competitor. These evaluations are based on scientific, qualitative and quantitative surveys of consumers. The consumer's ratings are graphically depicted as well. This comparison with competitors will identify the opportunities for improvement. This section of the HOQ is directly linked to the company's strategic vision (Costa et al., 2001).

The next room is the *relationship matrix*. The main function of this part of the HOQ is to define and clarify the relationship between the CA's and the EC's and is designed to improve the product. This part is referred to as the "body" of the HOQ. Construction of these relationships is portrayed by symbols indicating a strong, medium or weak relationship. The symbols, in turn, are assigned respective indexes such as 9-3-1, 4-2-1, or 5-3-1. This assignment of relationships is based on internal expertise, consumer surveys or data from statistical studies and controlled experiments. This is another critical step in the development of the HOQ. If a standard EC does not affect a CA, it may be redundant to the EC list on the HOQ, or the team may have missed a consumer attribute. A CA unaffected by any EC means that the EC still has to be formulated.

The *technical correlation matrix*, which is often called the Roof of the HOQ, is used to facilitate the development of relationships between different technical requirements and, thus, helps to identify where these units must be aligned to prevent a conflict in design. For engineers, this is the most important part of the HOQ, as they use it to balance trade-offs. This distinctive roof matrix helps engineers to specify the various engineering features that need to be improved collaterally. A variety of symbols can be used to represent the type of impact the requirements have on each other. These symbols are entered into the cells where the correlation needs to be indicated (Charteris, 1993).

The last matrix contains the *technical priorities/benchmarks and targets*. Once a team has identified the voice of the consumer and has linked it to the engineering characteristics, it needs to add objective measures at the bottom of the HOQ, beneath the ECs to which they pertain. When these objective measures are known, the team can start to establish target values. The final output of this matrix is thus a set of target values for each technical requirement that needs to be met when revising or making a new product. Based on this final matrix, conclusions can be formulated. In this HOQ the target values, their difficulty to accomplish, the absolute and relative weight of each EC as a contribution to the consumer's needs are presented.

In a following step of the QFD method, the information gathered in the HOQ needs to be cascaded into further process/product design activities and marketing stages with additional matrices. These subsequent matrices in the QFD contain activities on deployment of quality function and are not further discussed in this paper.

There are many forms of the HOQ, but its ability to be adapted to the requirements of a particular problem, makes it a very strong and reliable system to use in several sectors. Although the QFD method has been used in the food industry since 1987, adaptations are necessary to meet the specific requirements of the food industry. Garcia et al. (2007) state that the large number of consumer demands, the possible interactions between attributes and the possibility that some product requirements affect more than one consumer demand are the major bottlenecks when using HOQ in new food product development. Previous research has also recommended the HOQ as a planning tool to help management in making decisions when developing or improving food products or processes (Charteris, 1993, Chan and Wu, 2002, Acur et al., 2012, Sharma et al., 2008).

To date, there are few published applications of QFD in the improvement of food product development processes, especially on an industrial level. Costa et al. (2001) proposed a new structure for the HOQ in which the relationship between sensory analysis, instrumental analysis and consumer requirements are highly detailed (Figure 6. 2). The authors used this model for the translation of the consumer requirements into sensory attributes measurable by descriptive sensory analysis (Bech et al., 1994). Vatthanakul et al. (2010) used consumer and market information in the HOQ to identify technical product specifications. Their research shows that the HOQ can also be applied to marketing aspects of the product and not only to process-related characteristics.

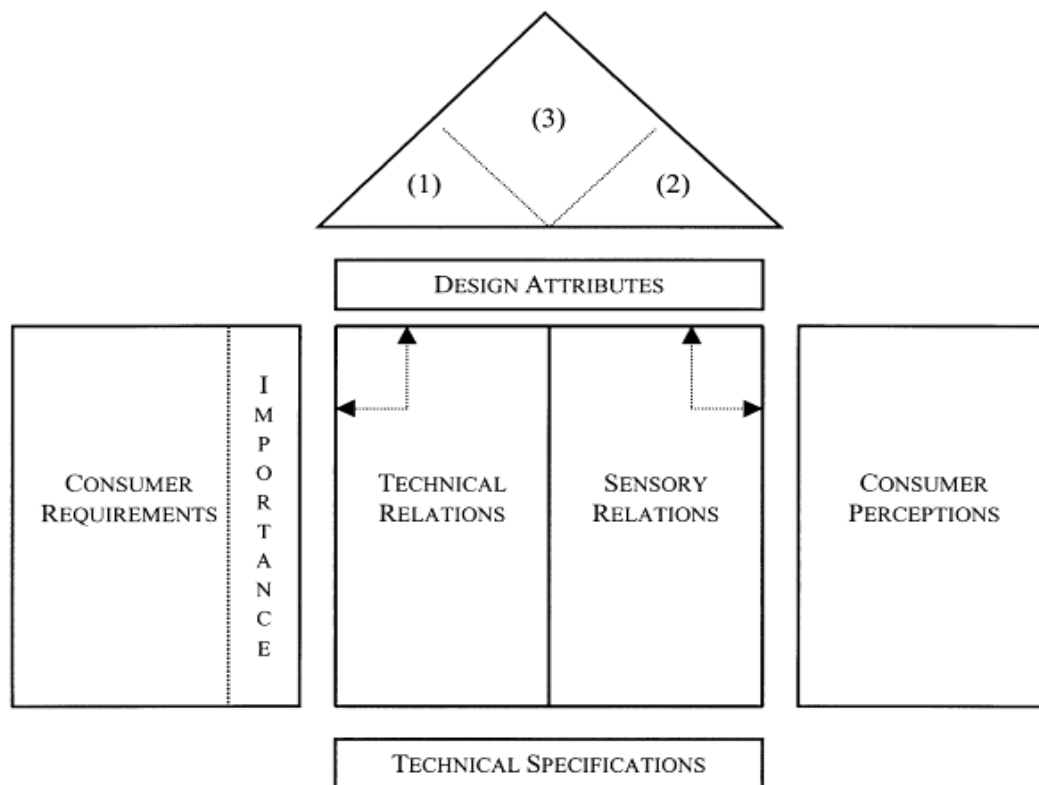


Figure 6. 2: Modified House of Quality for food product development: (1) interactions between technical attributes; (2) interactions between sensory attributes; (3) interactions between technical and sensory attributes (Costa et al., 2001)

By using consumer needs and competitive analysis, the HOQ helps to identify the technical components that require change. It may be possible that issues are addressed that never have surfaced before. These issues are then driven through the other matrices to identify the critical parts, manufacturing operations, and quality control measures needed to produce a product that fulfils both consumer and producer needs within a shorter development cycle time.

The net effect of all this is that the items that drive the company's actions are driven by consumer's requirements. There is an increased focus on the consumers and an increased awareness of their wants. Because of this focus, the process leads to improved consumer understanding and the ultimate outcome – a satisfied consumer. The HOQ helps to set targets, summarize basic data, represents the consumer's voice and helps to discover strategic opportunities.

However, since the applications of HOQ in the food industry are rare, the following case study investigates if the method is as easy to apply as proposed in the scientific literature and to assess options for improvement.

6.3. Case of European filled chocolates

This case study deals with the application of the adapted HOQ method (Costa et al., 2001) for assessing the characteristics that determine the product quality and consumer acceptability of filled chocolates and to link these expectations and needs to measurable and modifiable parameters.

Filled chocolates are known to be complex food products that consist of a chocolate shell and specific filling (Popov-Raljic et al., 2010). During the production of the chocolate shell, there are many process parameters that influence the quality of the chocolate and, later on, the quality of the filled chocolates. Next to that, the filling can consist of a wide variety of ingredients which all contribute to the taste and other sensory characteristics of filled chocolates (Andrae-Nightingale et al., 2009).

For the Belgian chocolate industry, maintaining premium quality of the filled chocolates is necessary despite the many critical parameters. Nonetheless, fat bloom formation on the chocolate shell of the filled chocolates is an important product defect that is currently getting a lot of attention from producers. Research has proven that recrystallization is causing this defect (Depypere et al., 2009b, Afoakwa et al., 2009b, De Graef et al., 2005). Next to optimization of the process parameters, such as tempering temperature and temper index, the ingredient composition seems to be influencing the fat bloom formation. Moreover, the formation of fat bloom is influencing the sensory characteristics of the filled chocolates (Popov-Raljic and Lalicic-Petronijevic, 2009). This will alter the preference and the acceptance of the consumer towards the product. Therefore it is essential to gain knowledge on the sensory differences between fresh and bloomed filled chocolates in relation to consumer preferences.

Further, the influence of process parameters and the effect of optimizing these parameters on fat bloom formation and the resulting sensory characteristics needs to be taken into account (Afoakwa et al., 2009c, Afoakwa et al., 2008c). As previously stated, the HOQ is a good tool to show the relations between the product attributes and the process characteristics.

6.3.1. Material and methods

6.3.1.1. Samples

The HOQ is built for two different variants of filled chocolates composed of identical dark chocolate shell and different hazelnut filling. The first filling had a low hazelnut oil concentration, the second filling had a higher hazelnut oil concentration (Table 3. 1). Moreover, each variant was produced in two countries, Belgium and Hungary. In Hungary, an SME (Szamos) was responsible for the production whereas in Belgium, the filled chocolates were produced by the Cacaolab from Ghent University. The production procedures were

different as the production in Szamos was industrial whereas the filled chocolates in Belgium were handmade. However, identical ingredients were used during the production. Accordingly, the following abbreviations for the samples are used in this paper: V1Be (low hazelnut oil concentration + produced in Belgium), V1Hu (low hazelnut oil concentration + produced in Hungary), V2BE (high hazelnut oil concentration + produced in Belgium) and V2Hu (high hazelnut oil concentration + produced in Hungary).

As the aim of the project is to investigate the effect of blooming, these filled chocolates were stored at three different conditions, namely constant temperature of 20 °C, fluctuating room temperatures (natural cycling in an office) and -18 °C (in order to keep the filled chocolates fresh).

After storage of the four different samples in three conditions, a total of 12 different types of filled chocolates were available for consumer testing. As this number was too high both for consumer testing and for incorporation in the HOQ, a limited number of samples was selected for the study. After storage for five months, little blooming was observed on the filled chocolates stored at 20 °C and therefore these filled chocolates were not used for the study. An agreement was made to use the fresh (stored at -18 °C) samples and the filled chocolates stored at fluctuating room temperature, as blooming was observed on these filled chocolates. This selection was supported by the colour and texture measurements on all samples. Consequently, for every selected variant a fresh and a bloomed filled chocolates were used in the consumer test. The selected products were V1Be-fresh, V1Be-bloomed, V2Hu-fresh and V2Hu-bloomed.

6.3.1.2. Consumer test

The aim of this first step is to identify the relative importance of the sensory characteristics of the filled chocolates for the consumer. In this study, this is done through quantitative surveys. However, it is also possible that the importance is defined through the team members' direct experience with consumers. These importance ratings were defined through a consumer test in which respondents were asked to indicate how important sensory characteristics are when consuming chocolate products. The respondents had to rate "It is important for me that the product smells nice", "It is important for me that the product looks nice", "It is important for me that the product has a pleasant texture" and "It is important for me that the product tastes good" on 7-point scale with 1 = 'not important at all' to 7 = 'very important'. These questions are items in the Food Choice Questionnaire developed by Steptoe et al. (1995), related to the factor "sensory appeal". This data was collected as described in section 4.3.2. Table 6. 1 shows the socio-demographic characteristics of the respondents.

Table 6. 1: Socio-demographic characteristics of the total sample and by nationality (in % of respondents) (cfr table 4.2)

	Total (N=859)	Belgian (N=459)	Hungarian (N=400)		Total (N=859)	Belgian (N=459)	Hungarian (N=400)
Gender				BMI			
Female	60.8	60.1	61.5	<18.5	4.6	6.1	2.9
Male	39.2	39.9	38.5	18.5-24.9	60.9	64.9	56.3
				25-29.9	25.5	22.7	28.8
Watch weight?				>30	9.0	6.3	12.0
No	40.7	40.5	41.0				
Yes	59.3	59.5	59.0	Age			
				<18	0.9	1.1	0.8
Where do you live?				18-30	46.1	53.8	37.3
City	66.0	37.5	98.8	31-50	40.1	36.2	44.5
Countryside	34.0	62.5	1.2	51-70	12.7	8.8	17.3
				>70	0.2	0.2	0.3

6.3.1.3. Critical process parameters and evaluation of properties of filled chocolates

Technical and sensory specifications

During the production, several production parameters were selected as indicative for the production of the filled chocolates. These parameters were used in the HOQ as technical specifications. In the production of the chocolate the first heating, the cooling and the second heating are important for the quality of the chocolate. Further, the temper index and chocolate tempering unit (CTU) of the chocolate is important for the texture of the chocolate and, specifically, for the hardness and possible fat bloom. For the filling, heating, cooling and end temperature were taken into account as quality parameters. These parameters were noted during the production of all chocolates. The production parameters for the most preferred filled chocolates were included in the HOQ as target values in the room for technical properties and targets.

Further, texture and colour measurements were conducted to provide two other parameters as technical specifications. The description of these measurements is already presented in section 3.2.2.4.

6.3.1.4. Sensory analyses

Quantitative descriptive analysis

The aim of the sensory measurements was to establish target values of the most preferred product as input for the HOQ. This was done by conducting quantitative descriptive analysis (QDA) with a trained sensory panel. The training of the panel and the QDA methodology was already thoroughly described in section 3.2.2.3.

Acceptance testing

In total 102 Belgian and 120 Hungarian participants were selected out of the initial 849 respondents in the consumer test for an evaluation of the filled chocolates. The selection was based on socio-demographic values and availability of the respondents to perform the sensory tests at the UGent SensoLab (Belgium) or the sensory lab at Campden BRI (Hungary). These two identical tests were set-up at a sensory lab again according to the regulations of a CLT test. However, due to the lab environment, the influencing factors could be controlled. All the respondents were placed in separate booths and other influencing factors were kept as low as possible (Lawless and Heymann, 2010). Due to the close collaboration and thorough preparation from both sensory labs, both tests were identical which enabled the researcher to compare the results from both countries. As incentive, coupons from a bookstore were distributed via lottery. First, the respondents indicate their liking for the product on a 9-point scale with anchor words (1 = Dislike extremely to 9 = Like extremely). Second, they rate the samples on overall appearance, aroma, texture and flavour on a 9-point scale with anchor words (1 = Dislike extremely to 9 = Like extremely). The filled chocolates were presented with a three digit code on white plastic plates.

6.3.1.5. Integration of the results in the House of Quality

Data from the consumer test, instrumental analyses and sensory analyses were integrated into the model of the HOQ according to the most preferred product, as perceived by the consumers. The general format consists of six major components: customer requirements, technical requirements, planning matrix, relationship matrix, technical correlation matrix and technical priorities/benchmarks and targets.

6.3.2. Results and discussion

6.3.2.1. Consumer test

In this study, the HOQ focuses on the sensory aspects of filled chocolates. Therefore, appearance, aroma, texture and flavour were selected as the consumer needs. Each of these four aspects of the 'voice of the consumer' were analysed separately. The results indicate that, for both nationalities, taste is the most important characteristic (Table 6. 2). There is no significant difference between the importance of taste for the Belgian and the Hungarian consumers, whereas smell, appearance and texture are significantly more important for Hungarian consumers than for Belgian consumers.

Table 6. 2: Mean values for the Hungarian and Belgian consumer needs for smell, appearance, texture and taste

	Hungary	Belgium	Mean
Smell	6.12 ^a	5.51 ^b	5.79
Appearance	6.10 ^a	5.46 ^b	5.76
Texture	6.13 ^a	5.36 ^b	5.72
Taste	6.34 ^a	6.35 ^a	6.34

^{a,b}, Means within the same row with different letters are significantly different.

6.3.2.2. Sensory analyses

Acceptance test with consumers

In the final stage of product development or improvement, the opinion of the consumer is essential for the product producer. Therefore the HOQ is based on the most preferred product. Data analysis derived from evaluations of the four samples showed that the V2Hu-fresh is preferred by both Hungarian and Belgian consumers although there is a significant difference in the level of liking between the Hungarian and Belgian consumers (Table 6. 3).

Based on these results, it was agreed to build the HOQ on V2Hu-fresh and consider the other three filled chocolates as competitor products. The liking of V1Be-fresh was lower for both groups of consumers. This can be due to the fact that these filled chocolates were handmade and therefore could have little deformations, whereas the V2Hu-fresh samples were produced industrially, which gave them a more uniform appearance. Both bloomed filled chocolates were disliked by the consumers, although the dislike of the Hungarian consumers was significantly lower than the dislike of the Belgian consumers. When taking into account that the liking of the fresh filled chocolates was also higher for the Hungarian consumers, it shows that Hungarian consumers made more use of the range of the evaluation scale than did the Belgian consumers. Belgian consumers tended to use the middle part of the scale and rarely scored in extremes.

Table 6. 3: Mean values for overall liking of the Hungarian and Belgian respondents for the selected samples

	Hungary	Belgium	Mean
V1Be-bloomed	3.95 ^a	5.62 ^b	4.78
V1Be-fresh	6.04 ^a	5.79 ^a	5.92
V2Hu-bloomed	4.36 ^a	4.99 ^b	4.67
V2Hu-fresh	7.22 ^a	6.53 ^b	6.87

Means within the same row with different letters are significantly different.

Quantitative descriptive analysis with trained panel

As the aim of the research was to find out which sensory attributes drive consumer preferences, the filled chocolates that were evaluated by the consumer, were also characterized by the trained panel. To determine the target values of the sensory attributes necessary for the HOQ, the most preferred filled chocolates (V2Hu-fresh) were evaluated by the trained panel (Table 6. 4) as in section 3.2.2.3.

Table 6. 4: Mean values for sensory attributes evaluation by the trained panel (n=8) of V2HU-fresh

Appearance		Aroma		Texture		Flavour	
Gloss	7.0	Chocolate	6.3	Snap	6.9	Chocolate	6.1
Intensity of colour	7.0	Sweet	4.9	Hardness	6.4	Hazelnut	6.6
Blooming	0.0	Bitter	3.3	Melting in mouth	4.9	Alcohol	0.0
Cracking	0.0	Sour	0.0	Greasiness	6.3	Sweet	5.3
Air bubbles	0.6	Burned	2.4	Smoothness	8.1	Bitter	3.1
Leakage	0.3	Hazelnut	6.4	Density of filling	7.6	Sour	0.0
		Alcohol	0.0	Homogeneity of filling	8.7	Specific	1.9
						Aftertaste	7.0

6.3.2.3. Technical and sensory specifications

The production parameters were noted during the production of V2Hu-fresh, the most preferred filled chocolate. Together with the results of the hardness and colour measurements of the V2Hu-fresh, these parameters were integrated in the HOQ as the target values. The results indicated that a hardness of 62 N and that a WI of 27 should be set as target values. The target values for the production of the chocolate shell were defined as 45 °C for the first heating, 29 °C for cooling, 31 °C for the second heating. A temper index of 5 and a CTU of 24 °C were used as indicative for the chocolate tempering. These values were within the range of well-tempered chocolate. For production of the filling, target values of 45 °C for heating, 26 °C for cooling and 29 °C for end temperature were noted.

6.3.2.4. Integration of the results in the House of Quality

The voice of the customer

The mean values for the consumer needs (Table 6. 2) were inserted in the HOQ as the importance ratings for the different consumer attributes, also referred to as the “Whats” in HOQ literature. These weightings are displayed, usually in terms of percentages, in the HOQ next to the corresponding CA’s (Govers, 1996). Figure 6. 3 displays the CA’s in the left chamber. Both the absolute and the relative importance are given.

Technical requirements

The EC’s are all internal characteristics of the product and are, thus, the sensory attributes of the product and the critical production parameters. The 28 characteristics (Table 6. 4) are the differentiators between products and are as such included in the HOQ. The crucial process parameters of the production, as they can be altered to influence the CA’s, are included as well.

Planning matrix

In this study, a planning matrix is presented in which the preferred product, V2Hu-fresh, is compared to the other products in the group: V1Be-fresh, V1Be-bloomed and V2Hu-bloomed. Mean ranks of the evaluation of the consumers for appearance, smell, texture and taste were used (Table 6. 5). The graphical representation of the results is for a more intuitive understanding of the values. The results indicate that fat bloom has the lowest influence on the aroma of the filled chocolates. Although the decrease is significant, it is not that large. These results also indicate that neither ingredients nor production method had an influence on the evaluation of aroma of the filled chocolates. However, the results indicate that fat bloom had a large effect on appearance, texture and taste. The evaluation of the appearance decreased the most, although the means indicate that the decrease between V1Be-fresh and V1Be-bloomed is smaller than the decrease between the V2Hu-fresh and V2Hu-bloomed. This indicates that the level of hazelnut concentration influenced the fat bloom formation.

The significant difference between the V2Hu-fresh and V1Be-fresh confirms that the higher liking of V2Hu (Table 6. 1) can be due to the uniformity of the appearance of the filled

chocolates that are produced industrially. The evaluation by the consumers of the texture and taste of the four samples gives similar results. For the fresh samples, the texture and the taste of the V2Hu samples were significantly better than for the V1Be samples. This again confirms the overall higher liking of the V2Hu samples (Table 6. 3). The difference can be due to the higher level of hazelnut oil concentration which makes the filling softer and perhaps increases the intensity of the hazelnut flavour of the filling. However, that possibility was not analysed during this study.

Table 6. 5: Mean values of the liking scores of appearance, smell, texture and taste of the selected chocolates

	Appearance	Smell	Texture	Taste
V2Hu-fresh	7.5 ^a	6.7 ^a	6.8 ^a	6.9 ^a
V1Be-fresh	7.0 ^b	6.5 ^a	5.9 ^b	6.1 ^b
V1Be-bloomed	5.5 ^c	6.1 ^{a,b}	4.6 ^c	5.3 ^c
V2Hu-bloomed	4.3 ^d	5.8 ^b	5.1 ^c	5.2 ^c

^{a,b} Means within the same column with different letters are significantly different.

Relationship matrix

The central part of the HOQ in this study was established through extensive literature review and experience with the sensory characteristics and production procedure. The attributes that belong specifically to one of the four constructs receives a value of 9. For example gloss, intensity of colour, blooming, cracking, air bubbles and leakage are strongly related to appearance. For the sensory attributes, the strong relations are rather easy to determine. For the process parameters, most of them are highly related to texture. First heating of the chocolate is moderately related to texture, and whiteness index is high related to appearance.

Some of the attributes have an influence on several constructs. For example, blooming is also moderately related to texture, as blooming indicates that oil has migrated through the filled chocolate, which has an effect on its texture. On the other hand, hardness, melting in mouth and smoothness also are affected by the blooming, which means that a change in these three attributes will result in a change in appearance. These attributes get a score of 3 in the relationship matrix.

Finally, there are some attributes that have a small influence on another construct than the one to which they are assigned. All the flavour attributes have an influence on the aroma of the product and vice versa. Gloss, cracking, air bubbles and leakage have a small effect on the texture of the product. These last four attributes also influence the flavour of the filled chocolates and get a score of 1 in these parts of the matrix.

Technical correlation matrix

In this study, the roof of the matrix gives the interaction between different sensory attributes and process parameters. For example, when changing the gloss of the product it will have an effect on intensity of colour, blooming, cracking... Some of these influences are positive effects, others are negative. With the roof of the matrix, the engineer knows that changing one attribute can change one or more other attributes. In the case of filled chocolates, the

roof indicates that gloss is positively related to the colour intensity of filled chocolates. Next to that, it is also positively related to hardness, melting in the mouth and smoothness of the chocolates. The tempering of the chocolate has a high impact on the gloss of the chocolates but also on the texture of the chocolates. A well-tempered chocolate will not develop fat bloom in an early stage. Moreover, a good tempered chocolate will have a preferred texture, which means that it will melt in the mouth as intended, that it will be just hard enough to bite through and that there will be no graininess in the chocolates during melting. Therefore, gloss is also positively related to all the process parameters in the production of the chocolates, the hardness measured with instrumental analysis and the WI.

Another example is fat bloom, which is negatively related to chocolate, sweet and bitter aroma, to snap and hardness, to density and homogeneity of the filling, to chocolate, bitter and sour flavour and aftertaste of the filled chocolate. The negative relation to the different aromas and flavours is due to storage. Fat bloom occurs after prolonged storage, causing the intensity of aromas and flavours to decrease. This relationship is rather indirect. The recrystallization that is causing the fat bloom has an impact on the homogeneity and the density of chocolate fillings. This recrystallization will also affect the snap and hardness of the filled chocolates. These are only two of the interactions that are visible in the roof. The higher the knowledge of the engineers, the more detailed this roof will be and the better these relations will be defined.

Technical priorities/benchmarks and targets

The target values for the sensory characteristics are the mean values that the trained panel has determined during QDA for the filled chocolate on which the HOQ is made, V2Hu-fresh (Table 6. 4). For the process parameters, the recording of these parameters during the production of V2Hu-fresh are included. The difficulty to accomplish changes in these attributes and parameters is given on a scale of 0 (Easy to accomplish) to 10 (Extremely difficult) and is based on thorough literature study. The absolute weight is the sum of the multiplication of the importance ratings of each CA with the corresponding values in the relationship matrix for this attribute. After ranking of these absolute weights, a relative weight is assigned to every attribute.

6.3.3. What can the House of Quality teach us in the case of filled chocolates

The complete HOQ, for the four variants is built on the product V2Hu-fresh (Figure 6. 3). From the relative weight presented for the customer requirements (WHATs), it can be concluded that flavour is the most important criteria for a consumer in relation to the sensory attributes of a filled chocolate. From the competitive analysis it is clear that the main differences between the filled chocolates are found in appearance and texture, and to a lesser extent in aroma and flavour. The respondents were asked to give the overall liking for appearance, aroma, texture and flavour and not specifically for the couverture chocolate or the filling

separately. Given that there is a difference in overall liking of the fresh filled chocolates V1 and V2, this indicates that the filling has an influence on liking scores. Based on these results, one might conclude that there is little difference in the liking scores for the four filled chocolates. However, this is contradicted by the results given in

Table 6. 3. These results show that the liking of the filled chocolates decreases after blooming. This information cannot be captured based on the way the HOQ is commonly presented. This can be solved by adding the information of overall liking in the room of competitive analysis.

The target values coming from the sensory analysis indicated that consumers expect a high standard for texture attributes such as smoothness, density of the filling and homogeneity of the filling. As a food producer, it is therefore important to keep this in mind when producing a filled chocolate. Next to that, the attributes gloss, intensity of colour and snap have high target values. From the roof (technical correlation matrix) of the HOQ, it is clear that these attributes are related to each other and to the tempering of the chocolate. This is presented by the '+'-signs at the intersection of the attributes gloss, intensity of colour, snap on the one hand and tempering on the other. Thus, tempering can be viewed as a critical production parameter when producing or improving a filled chocolate.

Knowing that flavour is the most important factor for consumers in their acceptance of filled chocolates, it is important to make a filled chocolate with flavour intensities that are just right for the consumer. From the target values, the intensity of the hazelnut, chocolate and sweet flavour needs to be high, followed by a lower, but recognizable, bitter flavour and a touch of a spicy flavour. Aftertaste of the filled chocolates should be clearly present according to what the trained panel indicated for the most preferred filled chocolate.

The results of the relative weight in the last matrix of the technical properties indicates that blooming is the first thing that needs to be controlled. Knowing that this is also the most difficult parameter to change, the HOQ indicates that this is the biggest challenge for filled chocolate producers today.

Further research on this topic is necessary to improve the production process for filled chocolates and to increase the storage time before blooming occurs.

It is possible that the food producer wants to incorporate more information in the HOQ. As stated in the introduction, the company can expand the HOQ to fit their needs, as it is possible to custom-build the HOQ. To the column of CAs, they can add other columns for histories of consumer complaints. Some may want to add data from the sales force to the list of CAs to represent strategic decisions. In the room of the ECs, the team can add the costs of servicing these complaints or a row to add the technical difficulty of the ECs.

6.4. *Recommendations for the QFD method*

This HOQ was specifically set-up for V1-V2 samples and therefore the specific results cannot be transferred to other products. However, this HOQ exercise was performed for V3-V4 and V5-V6 samples (Table 3. 1) and although the information for the type of filled chocolate was slightly different, the overall conclusion can be used for all applications of the HOQ. The HOQ is, first of all, a living matrix which can serve as an immediate source for improvement of products or related products. Although it can serve as a great communication tool at each step in the process, the matrices are the means and not the end of the product improvement process. Its purpose is to serve as a vehicle for dialogue to strengthen vertical and horizontal communications.

Through defining the consumer needs and conducting a competitive analysis, the HOQ helps to identify the technical components that require change. The net effect of all this is that the items that drive the company's actions are driven by consumer's requirements. The HOQ helps to set targets, summarize basic data, represent the consumer's voice and helps to discover strategic opportunities.

However, the HOQ is rarely used in daily product development in the food industry. This contradicts with the benefits that are promised. This can be due to several factors. First, a thorough knowledge of the QFD method and construction of the HOQ is necessary. Therefore, a company needs an expert in this field. This person should be able to relate to several internal departments, in order to work effectively.

Second, a lot of data needs to be collected and analysed. This can be a problem, since several departments within the company need to deliver the data. For example, consumer data can be collected from the marketing department whereas sensory analyses should be performed by an expert in this topic. Next, the instrumental analyses should be conducted in the engineering lab. The relationship matrix and the roof of the HOQ need to be put together by experts in these fields. These people need to come to agreement and set target values for the engineering characteristics. Therefore, it is important that the management of the company supports this methodology in order for it to work.

Third, the HOQ contains large amounts of data, which makes working with it difficult. The data can be reduced by performing factor analysis on the sensory data. However, when interpreting the final HOQ afterwards, this can lead to a loss of data and, therefore, is not recommended (Moskowitz and Kim, 1997). With factor analysis, several items will be grouped and are given a factor name. Not all the items that are included in one specific factor will have a high factor loading and will, thus, be of little relevance. A recommendation can be to include a second HOQ, which explains the content of important factors, can provide a solution to the problem of loss of data.

Fourth, it can be difficult to present the findings from the HOQ to other people who are not familiar with the method. The figure is very large and contains a great amount of data that makes it difficult to interpret without losing the overview. Next to that, the case of the European filled chocolates shows that data, such as overall acceptance, can get lost in the HOQ. Moreover, the HOQ is only a first step in a time-intensive procedure for product development or improvement. It does not give clear solutions to the engineers, R&D people or marketing people. It only gives an indication of which points upon which they need to focus when they perform an in-depth analysis.

Fifth, filling in the planning matrix can be subjective and vague when it is only based on literature or experience from the persons who are constructing the HOQ. Park et al. (2012) recommend to use fuzzy set theory in order to get a more objective approach. This methodology is briefly described by Park et al. (2012) and more thoroughly explained by Kwong et al. (2007). Further research on this topic is necessary, as this methodology is quite technical and would require good knowledge and skills from the persons constructing the HOQ within a food company.

6.5. Conclusions

The case study of the European filled chocolates clearly marks that the HOQ only indicates what might already be known by the producers of these filled chocolates. The question arises if the HOQ can really be used in the food industry or if possible adjustments can lead to a more hands-on tool for new product development (Benner et al., 2003a). Garcia et al. (2007) point out that product development in the food industry is difficult, because food products cannot be described as a set of attributes. For these products, it is the interaction between the set of attributes that defines the consumer satisfaction. The HOQ can be an ideal way to present this, as one engineering characteristic can affect more than one consumer requirement and vice versa. Garcia et al. (2007) comment that defining these interactions is an advantage of the HOQ but that it is a challenge to define them correctly.

There is an increasing demand for a well-defined procedure that, in a structured way, leads to new product development (Moskowitz and Hartmann, 2008, Moskowitz et al., 2006) which suggests that there is a future in this field of research. The development of such a tool can be done by a combination of personal interviews with the producers, stakeholders and policy makers in the food industry and a thorough study of the existing models for new product development. As a final remark, a combination of HOQ and Chain Information Model (CIM), as explained by Benner et al. (2007), is recommended for further innovation in the food industry. CIM is a method that helps to identify the necessary information for product development and facilitates information exchange in the food production chain (Benner et al., 2003a). By combining these two techniques, which cover the internal process of product development (HOQ) and the development process in the chain (CIM) with the consumers' needs as a starting point, new food product development can have a higher success rate.

However, it might be interesting to recycle the information gathered to build the HOQ and implement it in a more practical method for product development. As already indicated in the introduction (section 1.1.1.1), is the Stage-Gate® process a frequently used method for product development in the food industry. Similar to the QFD method, it is a method which requires the input of R&D department, production, marketing and finance. It also comprises necessary aspects such as a competitive analysis, voice of the customer or a technology assessment. Both are thus composed of a set of information gathering activities. However, the QFD differs from the Stage-Gate® method because the Stage-Gate® incorporates all the steps before the defining of the product. It incorporates three stages (discovery, scoping and building business case) before the product is actually developed. Whereas QFD starts mostly from a final product, as many data needs to be gathered for which at least a tangible product is necessary, the Stage-Gate® process starts from an idea. This makes it a very hands-on approach for a company to assess the viability of a product idea.

Chapter 7

The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis

Adapted from:

De Pelsmaeker, S., Dewettinck, K., Gellynck, X. (2013). The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis. *Trends in Food Science and Technology*, 29 (2), 108–115

Abstract

Conjoint analysis has proven to be a useful tool for consumer research in the food industry. Most of this research has focused on extrinsic attributes, although an increasing number of studies have also sought to incorporate intrinsic attributes. In the past, several researchers have successfully included these intrinsic attributes by using verbal or pictorial stimuli as attribute levels. However, given that taste is a key factor in the purchase decision process for food products, the development of conjoint analysis that incorporates levels of sensory characteristics could be a useful asset for the food industry.

7.1. Introduction

All products are a combination of different characteristics, or attributes, such as price, taste, appearance, packaging and labelling. The decision by a consumer to purchase a product is based on a complex trade-off between the different attributes of the various alternative products. In conjoint analysis, the product under consideration comprises several attributes. These attributes are selected by the researcher based on the study hypotheses, and this may result in the products being hypothetical. The key characteristic of conjoint analysis is that respondents evaluate a full product profile comprising combinations of attributes (Alriksson and Oberg, 2008b, Orme, 2010b).

Throughout the last decade, some researchers have criticised the application of conjoint analysis because it did not include a product's sensory characteristics. However, when conjoint analysis is conducted to identify consumer purchase decisions for food products, the aspect of taste does need to be considered. Further research on this topic is vital for innovation in the food industry. Therefore, several authors have attempted to use stimuli that contain information on sensory characteristics, or have even used tasting as a presentation method in conjoint analysis. The few studies that have sought to address this limitation are discussed, and further recommendations are given.

As extensive literature is available on conjoint analysis, and the focus of this review is on the applications of the method, it is sufficient to provide an introduction to the method in the first part of the article and to refer the reader to a list of articles where the method can be studied in more depth. The second part of the article reviews several applications of conjoint analysis within the food industry and some research studies in which these sensory characteristics are used as attributes in the conjoint analysis.

Thirdly, the opportunities and limitations for including tasting within conjoint analysis are formulated, as the development of a combined method will lead to better understanding and prediction of consumer behaviour and preferences. The knowledge gained will enable a meaningful dialogue between sensory analysts, market researchers and stakeholders in the food industry.

7.2. *Conjoint analysis: A research method*

Conjoint analysis is a technique for measuring the stated trade-offs consumers make concerning preferences and their intention to buy (Green et al., 2001). This market research method has been used for over forty years and has its origins in the 1920's (Green and Srinivasan, 1978). It started as a new development in mathematical psychology and was picked up by researchers as a new approach to quantify judgmental data (Green and Rao, 1971, Luce and Tukey, 1964). Hence, conjoint analysis has its roots in behavioural science, as well as economic science (Sammer and Wüstenhagen, 2006). The method has been regularly utilised in many fields of application, such as new product development, improvements to existing products, pricing policies, advertising, distribution, control, market segmentation and as a simulator of purchasing decisions (Gustafsson et al., 2007, Green et al., 2001, Alriksson and Oberg, 2008b).

Ares, Gimenez et al.(2009a) defined conjoint analysis as a stated preference method which is, thus, the opposite of a revealed preference study that describes the actual behaviour of respondents (Figure 7. 1). The latter method is difficult to apply within scientific research, new product development or innovations for existing food products, as it involves a significant investment in terms of time and money. Conjoint analysis appears to be a useful tool for the management of such applications since it predicts the future reactions of a consumer.

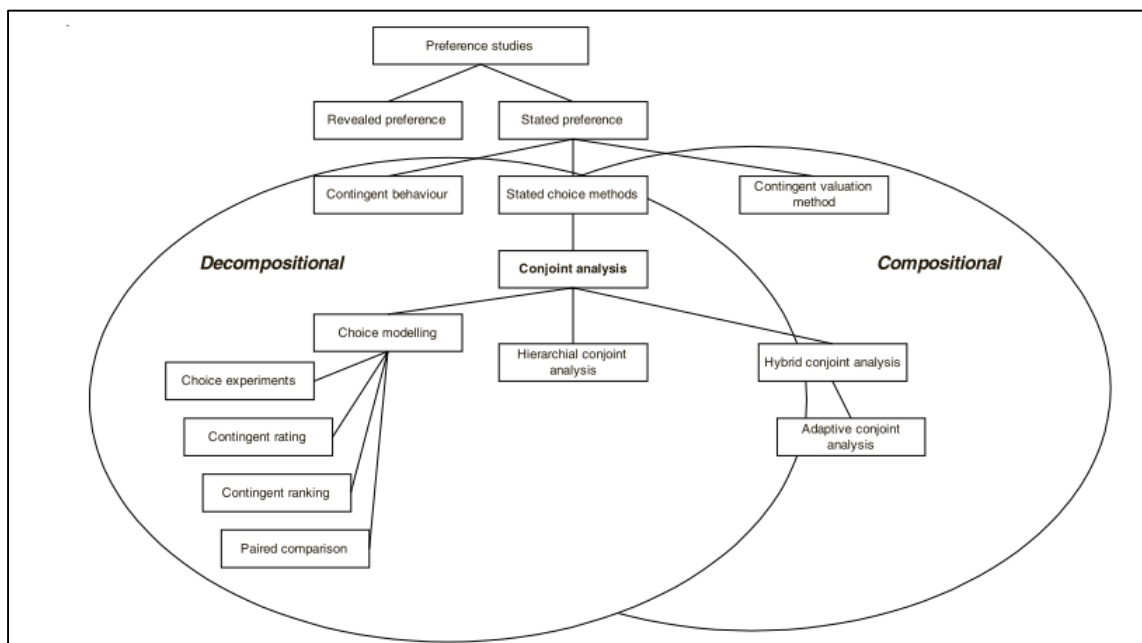


Figure 7. 1: Conjoint analysis methods (Alriksson and Oberg, 2008b)

7.3. Methodology of conjoint analysis

Conjoint analysis is often used to explore the interaction and effects of several product attributes on consumer acceptance (Green and Rao, 1971). The advantage of conjoint analysis is thus that it reveals the relative importance of the product attributes that are considered jointly by the respondent (Moskowitz and Silcher, 2006, Asioli et al., 2014). It can also provide information about the value of various levels of a single attribute (Green and Wind, 1975). The relative importance of these levels are called utilities. The contributions of the different levels and the importance of the various attributes itself are filtered out of the overall judgments (Gustafsson et al., 2007). Important is that a conjoint measurement has the ability to reconstitute the original global judgments with these utility scales (Green and Wind, 1975). Additionally, it is possible to mingle these utilities in new combinations to estimate the preference or purchase intention of a new product constructed of different attributes.

When conducting a conjoint analysis, three major steps are required: design of the questionnaire, method of data collection and the analysis of the data (Table 7. 1). Within these steps, several actions need to be respected.

7.3.1. Design of the questionnaire

After formulating the hypotheses and research question, the conjoint analysis has to be carefully designed. The researcher selects the attributes and the attribute levels for the conjoint analysis. This is done based on a literature study, a qualitative research or a combination of these two methods. It is important that the attribute levels are realistic and that the formulation of every attribute and level is clear for a consumer (Green et al., 2001, Alriksson and Oberg, 2008b).

Afterwards, a preference function is selected in which the preference for an object is assumed to be an additive function of the attributes and the attribute levels (Cattin and Wittink, 1982). Three models are common: an ideal point model, an ideal vector model and the partial benefit or part-worth model. As the latter model includes the two other models and because it is the most flexible, it is the most used model in the conjoint analysis (Gustafsson et al., 2007). The part-worth model assumes that preference for a product is an additive function of values (worths) of its components (attribute-levels) (Cattin and Wittink, 1982).

As a next step in the design of a conjoint analysis, an experimental set-up needs to be identified. The two core methods are the full profile method and the two-factor-at-a-time or trade off method (Lenk et al., 1996, Green and Srinivasan, 1978). Twenty years ago, a combination of these two methods, adaptive conjoint analysis (ACA), was developed and used for different applications (Green and Krieger, 1990). ACA consists of two tasks namely a self-explicated task in which the respondent rates the desirability and the importance of the attributes and a second task that comprises an evaluation of partial profiles, two at a time (Green et al., 1991).

After identifying the most suitable method, the best fitted design is selected. A researcher can choose to work with a complete design or a reduced design. When using a full factorial design, the amount of partial profiles rapidly increases with the amount of attributes and attribute levels (Wittink and Cattin, 1989). The number of profiles to evaluate cannot exceed a certain amount without a decrease in the validity of a consumer's preference judgments. Green and Wind (1975) suggested to use a fractional factorial design to reduce the number of profiles to a manageable size and maintain orthogonality.

After covering all these topics, the researcher needs to decide on the presentation of the stimuli. Numerous studies have dealt with the question if a chosen stimuli presentation influences the preference of a consumer or not (Green et al., 2001, Gustafsson et al., 2007, Gustafsson et al., 1999). It is crucial that respondents understand the questions and all attributes and levels. Traditionally, a verbal description or a paragraph is given as an explanation of the attribute or level. Nowadays, pictorial material is used to make the task more interesting and less fatiguing for a consumer. Moreover, in cases where conjoint analysis is used for new product development, researchers use experimental designed prototypes (Kessels et al., 2008, Wittink et al., 1994). When evaluating a new food product, it might be interesting to let the consumer taste and evaluate the product instead of just verbally describing the taste of the product.

Table 7. 1: Procedure to develop conjoint analysis: references

Steps	Actions	Reference
Design	-Deciding on attributes and attribute levels -Selection of the preference function -Identifying the data collection method -Selection of the data collection design -Deciding on stimuli presentation	(Cattin and Wittink, 1982, Green and Srinivasan, 1978, Green, 1984, Green and Krieger, 1990, Green et al., 2001, Wittink and Cattin, 1989, Gustafsson et al., 2007, Alriksson and Oberg, 2008b, Grossmann et al., 2002, Orme, 2010a, Orme, 2010b, Green et al., 1991, Carroll and Green, 1995, Lenk et al., 1996, Jaeger, 2000, Kessels et al., 2008)
Data collection	-Procedure of data collection -Measurement scales	(Cattin and Wittink, 1982, Green and Srinivasan, 1978, Gustafsson et al., 1999, Gustafsson et al., 2007, Alriksson and Oberg, 2008a, Wittink and Cattin, 1989)
Analysis	-Estimation method -Reliability and Validity	(Green and Wind, 1975, Cattin and Wittink, 1982, Green and Srinivasan, 1978, Wittink and Cattin, 1989, Alriksson and Oberg, 2008b, Gustafsson et al., 2007, Orme, 2010d, Moore, 1980, Green and Krieger, 1991)

7.3.2. Method of data collection

When conducting a conjoint analysis, the method of data collection is also very important. In this part, the researcher needs to decide on the procedure of data collection and select which measurement scales to use (Orme, 2010d). Several options for data collection are possible such as a paper based questionnaire, a mail or on-line survey, personal or telephone interview (Alriksson and Oberg, 2008a, Gustafsson et al., 2007). The choice will depend on the decisions made in the design of the conjoint analysis. The measurement scale used is also critical. Rating, ranking, paired comparison or choice based scales can be used (Alriksson and Oberg, 2008b, Gustafsson et al., 2007). The interpretation of every scale differs significantly. The most suitable scale for answering the hypotheses must be selected.

7.3.3. Analysis of the data

The collected data is analysed as additive functions of the attributes. The preference levels for each attribute can be determined by estimating the part-worth utilities of each level of the attributes. From these results it is possible to estimate the relative importance of the attributes for each individual or group of respondents. Three main categories are possible for the parameter estimation method in conjoint analysis depending on the measurement scales: interval, ordinal and choice based. With a dependent variable that is metric or interval scaled, such as in a rating-based study, ordinary least squares (OLS), multiple linear regression and analysis of variance (ANOVA) can be used (Alriksson and Oberg, 2008b). When an ordinal scale is used, such as in rating-based studies, non-metric methods may be used. Probabilistic models are used when the dependent variable is categorical, such as in a choice-based study. The selection of the method will depend on the data structure and the statistical model.

Reliability and validity are important in conjoint analysis as its managerial value is based on the ability to predict events in the marketplace accurately (Leigh et al., 1984). The reliability needs to be tested on the level of the input judgments of the respondent as well as on the level of the estimated parameters. For the validity, the external as well as the internal validity are tested (Cattin and Wittink, 1982). The results of a conjoint study are then used to segment the market to characterize these market segments.

The construction of a conjoint analysis is a time-demanding task. Other steps can be included in the development of a conjoint analysis as every product and every study has its own characteristics and hypotheses that focus on different things. The researcher needs to specify the overall framework of a conjoint study to the product in the study.

The aim of conjoint analysis is to calculate the relative importance of the product attributes included in the research. Therefore, these attributes comprise two or more levels that are relevant to the consumer (Figure 7. 2). It is important that the attribute levels are realistic, and that the formulation of each attribute and level is clear to the consumer (Green et al., 2001, Alriksson and Oberg, 2008b). An example of simple conjoint analysis is illustrated using

a hypothetical study in which tasting can be included as a presentation method in the conjoint analysis. The different attributes and levels are given in Figure 7. 2. There are 27 possible product profiles (3 prices x 3 brands x 3 levels of cocoa content). Rating of such large numbers of profiles is impractical and, therefore, fractional factorial design can be used which reduces the amount of full profiles that the respondents need to rate. Respondents are then asked to read the product profile (e.g. price A, brand A and cocoa content C) and rate their intent to purchase the sample on a 9-point category scale anchored with: “definitely would not buy” at 1; “may or may not buy” at 5; and “definitely would buy” at 9 (Haddad et al., 2007). However, a pairwise question can also be asked during a conjoint analysis. The respondent then has to indicate which product (profile) he/she would rather purchase. The scale is again a 9-point category scale with “strongly prefer left profile” as 1; “indifferent” as 5; and “strongly prefer right profile” as 9 (Orme, 2010b). For a more detailed explanation of the statistical analysis and interpretation, the reader is directed towards more specialised papers (Green and Srinivasan, 1978, Green, 1984, Green and Krieger, 1990, Green et al., 2001, Wittink and Cattin, 1989, Gustafsson et al., 2007, Alriksson and Oberg, 2008b, Grossmann et al., 2002, Orme, 2010a, Orme, 2010b, Green et al., 1991, Carroll and Green, 1995, Lenk et al., 1996, Jaeger, 2000, Kessels et al., 2008).

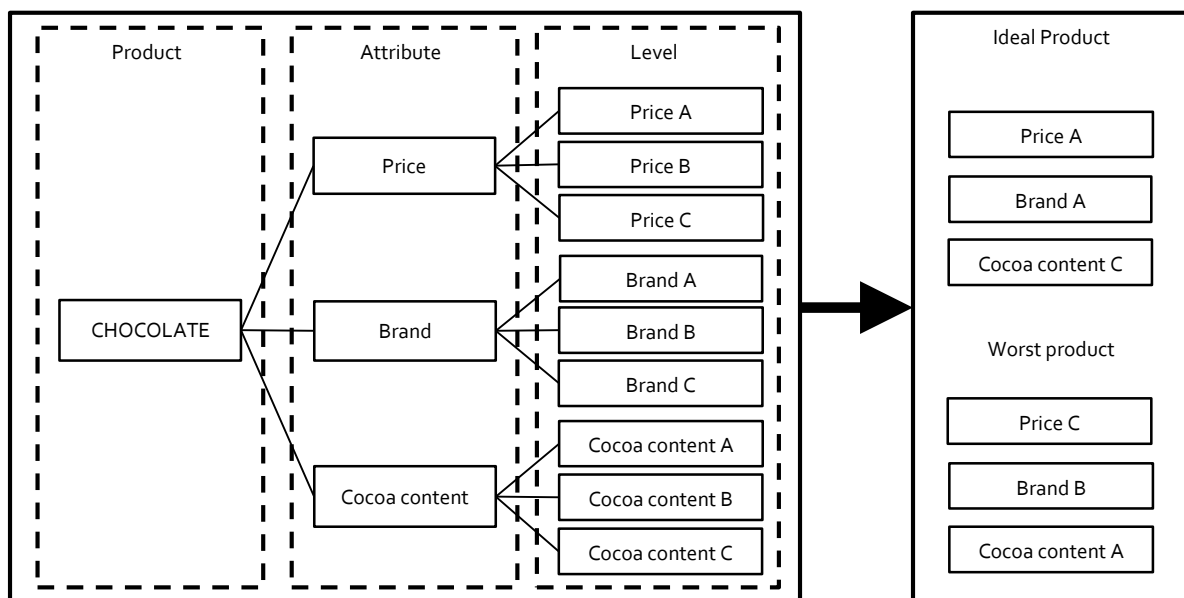


Figure 7. 2: Example of conjoint analysis experiment for chocolate, and calculation of ideal and worst product

Conjoint analysis thus provides information about the value of various levels of a single attribute (Green and Wind, 1975). The relative importance of these levels is reflected in their utilities. The contributions of the different levels, and the importance of the various attributes themselves, are revealed through respondents' choices (Gustafsson et al., 2007).

An important feature of conjoint analysis is its ability to mix these utilities in new combinations in order to estimate the preference or purchase intention for a new product

comprising different attributes (Green and Wind, 1975) (Figure 7. 2). Hence, it is possible to construct a most preferred or least preferred product for a specific consumer segment.

As stated above, the researcher then also needs to decide on the presentation of the stimuli. Traditionally, a verbal description, or a paragraph, was provided to explain the attribute or level. Nowadays, pictorial material is used to make the task more interesting and less tiring for the consumer. When evaluating a new food product, it is beneficial for food producers to allow the consumer to taste the product.

7.4. *Applications of conjoint analysis in the food industry*

Every product has its own characteristic attributes. In order to develop new products, or improve existing products, it is necessary to understand how consumers perceive innovative products and to define which factors attract consumers and positively influence their purchase decisions. The conjoint analysis is therefore helpful in identifying the importance of product attributes and understanding consumer behaviour (Grunert, 1997, Hailu et al., 2009, Saba et al., 2009, Schnettler et al., 2009). Enneking, Neumann et al. (2007) raise the problem that market research on food choice is mostly based on conventional surveys where respondents are pushed in a specific direction. Conjoint analysis can reduce overestimation of product attributes, as the interviewees do not know which attributes are of interest to the researchers.

7.4.1. The complexity of food products

One of the first steps in developing a conjoint analysis is the selection of the attributes and attribute levels. With food products, this is particularly difficult as they comprise a large array of attributes. These range from external attributes, such as price, packaging, product information, labelling and convenience, to internal attributes, such as taste, colour or smell. The quantity of attributes is usually too high for the use of a full factorial design, because the concepts that can be created are far too numerous. The risk of a potential fatigue effect increases when consumers are asked to rate a large number of samples. Fortunately, the option to use a reduced, or fractional factorial, design has now become available (Alriksson and Oberg, 2008b).

The use of conjoint analysis offers particular benefits for new product development. Product designers or marketers usually have little, or no, information as to what specific levels of each attribute need to be included in the product, as it is difficult to predict the sensory drivers underlying preference (Johansen et al., 2010b). With conjoint analysis, this problem can be resolved, as it requires at least two levels for each attribute.

Although the theoretical opportunities to apply the method have increased exponentially as the result of refinements to conjoint analysis and technological advancement, its application in the food industry is becoming more challenging. As innovation in the food industry is essential to survive, the producer is constantly seeking new ideas or improvements to satisfy the needs of the consumer. Moreover, consumers are becoming more demanding in terms of the convenience and health of food products, without a loss in taste.

Finally, all this needs to be achieved at the lowest price, as producers and marketers believe that price is one of the most important attributes that convinces consumers during the purchasing process. Therefore, the effect of price has been the subject of several studies in the past (Ares et al., 2009a, Carneiro et al., 2005, Nelson et al., 2005). Some studies have indicated that price is less important than other extrinsic attributes when buying, for

example, strawberry yoghurt (Vickers, 1993), milk desserts (Ares et al., 2009b) and cheddar cheese (Solheim and Lawless, 1996). The influence of price tends to be high when tasting is not involved in the study; this contrasts with findings where tasting is included in the study (Lee et al., 2007).

In all these latter studies, sensory quality has a primary effect on purchase intent; whereas extrinsic attributes have a secondary effect (Haddad et al., 2007, Helgesen et al., 1998). Extensive literature proves that, in addition to price, other attributes are relevant in defining preference or purchase intent. For the consumption of good quality beef, characteristics such as good taste, tender, juicy, fresh, lean, healthy and nutritious are very important for a consumer (Schnettler et al., 2009). Research on the consumption of wine indicated that a good balance between origin, price and year of production is required (Gil and Sanchez, 1997). Other attributes, such as food safety (Baker, 1998), production method (Frewer et al., 1997), or claims for functional foods and nutraceuticals (Hailu et al., 2009) were also investigated in studies using conjoint analysis.

Consequently, when performing a conjoint analysis for a specific product, it is important to identify the most relevant attributes for that product, and to include these in the conjoint analysis. Qualitative analysis is a first step in the selection of these relevant attributes.

7.5. Combining conjoint analysis with other tests

In the past decade, several researchers have conducted both sensory analysis and conjoint analysis during their consumer tests (Tuorila and Monteleone, 2009). As a result, they have gained a greater understanding on the influence of both the extrinsic and intrinsic attributes of a product. Enneking et al. (2007) stated that, in studies about purchase intention and preference, it is important to recognise the influence of both the extrinsic and intrinsic attributes of a product.

The most quoted criticism of sensory analysis over past decades is the difficulty in translating the results to marketing or sales departments. Frequently, the answers that sensory analysts provide do not match the questions identified by marketers, and vice versa. The quantity of statistics on one side and the quota for sales on the other has resulted in a communication gap between the two disciplines. Interestingly, this area has been identified by several authors as potentially the most profitable opportunity for innovation in the food industry. At a time when new products have substantial failure rates, it is necessary to cultivate and refine every possibility that can lead to successful innovative food products.

As indicated above, the most relevant attributes for product acceptance, and those with the greatest influence on consumer purchase decisions, need to be identified. Lee et al. (2007) presented a flowchart to identify the most relevant attributes for a conjoint analysis. Focus groups that, in the first stage, identify and, in the second stage, refine the selection of important attributes and attribute levels are used to set up the conjoint analysis. The results of the focus groups showed that the aspect 'sensory' is relevant to purchase intention.

As a first step, several studies have presented a method in which descriptions of sensory characteristics are included within a conjoint analysis. Moreover, some have even stimulated the respondents by using real or pictorial stimuli, instead of verbal descriptions of the sensory attributes. Therefore, several authors who have compared verbal, pictorial and real presentation, have shown that the presentation itself does not influence the conjoint analysis (Jaeger et al., 2001, Vriens et al., 1998, Strebinger et al., 2000). Green and Srinivasan (1990) argued that it is better to use real product models whenever possible. Jaeger (2001) note *"While a verbal representation may be satisfactory for price information, intrinsic product characteristics of food products, including appearance, taste and texture, are probably less adequately represented."*

Given that taste is a key factor in consumer acceptance, this parameter needs to be taken into account when developing new products. Consequently, not only is the knowledge of a product's sensory characteristics important, but also the actual tasting of the product itself. Research has indicated that second purchases, or product loyalty, are largely based on how well the food product meets the expectations and needs of the consumer (Grunert, 2003a). These expectations and needs are strongly related to the taste of the product. Despite

attractive packaging, low calorie or low fat levels, promised weight loss or other health benefits, low price or other external attributes, it is very unlikely that any consumer will buy the product a second time after they have tried it and disliked the taste. Consequently, several authors have sought to combine the results of a tasting session with the results of a conjoint analysis (Poelman et al., 2008). Moreover, only a few authors have explored the possibility of including the tasting within the conjoint analysis.

7.6. *Tasting as a part of conjoint analysis*

As a first step, several studies have tried to conduct a blind tasting in combination with a traditional conjoint analysis. The results of a blind tasting were then used to indicate a consumer's actual preference for a product. Several authors linked these results to the consumer's stated preference resulting from a conjoint analysis (Johansen et al., 2010b, Enneking et al., 2007, Helgesen et al., 1998). Further research was undertaken on incorporating tasting as a stimulus within the conjoint analysis. Therefore, this section reviews the various small steps towards the construction of a final working model.

7.6.1. Two-step method: blind tasting and conjoint analysis

Di Monaco, Cavella et al. (2007) carried out blind tasting before conjoint analysis. The authors wanted to identify the influence of technological information on soup acceptability. Other attributes, such as packaging, ingredients and seasoning, were included and verbally presented. However, one criticism is that the combination of blind tasting and conjoint analysis does not represent a real situation. Moreover, the results of the study clearly indicate the importance of selecting the correct attributes (Di Monaco et al., 2007).

Vickers (1993) examined the considerations that arise when combining tasting and conjoint analysis with sensory-related attributes to study the effects of sensory characteristics, brand, price and health claims on consumer purchase intentions for yoghurt. The aim of the study was to test the strength of memory on sensory characteristics and preferences. The experiment comprised three parts. The first part included tasting of the yoghurts, after which the consumers rated the products in terms of preference. Consumers were instructed to remember the taste of the samples for the second part of the experiment. Although, the various parts of the test were conducted at the same time, it is a demanding task for consumers to remember different tastes. Full profile conjoint analysis was applied in this second part. The sensory attribute was included using three levels: high, medium, low. The attributes in the conjoint analysis were all verbally presented. However, what constitutes a high sensory quality for one consumer may only be rated medium by another. Therefore, a less subjective description of the levels may provide better results. In the third part, the consumers re-rated the samples. The study revealed that sensory quality is very important in purchasing yoghurt, although the author raises the criticism that the strong focus on tasting and sensory attributes may have influenced the participants. Again, this study demonstrates the need for a well-developed experimental design.

Helgesen, Solheim et al. (1998) conducted a study on fermented lamb sausages, in which they combined tasting with conjoint analysis, using two sessions. The conjoint analysis was conducted during the second session. In this second session, the respondents rated their purchase intent based on tasting, along with information on fat and price levels. This means that, in addition to the verbal description of fat and price, real samples were used as stimuli

for all the senses by including tasting. The results indicated that the influence of taste preference is stronger for cheap and healthy products, indicating that a pleasant taste will influence purchase behaviour when price and the consequences for health are somewhat undesirable. The authors conclude that integration of sensory differences as factors in conjoint analysis is valuable. More specifically, it can be used to select the food product with the highest sensory preference, and also to gather product information for the target consumers.

7.6.2. Comparison: conjoint analysis with and without tasting

A study on regular fat and reduced fat Cheddar cheese used a different approach (Solheim and Lawless, 1996). Two conjoint analyses were undertaken, the first one with score cards giving verbal information on fat content and price level. During the second test, similar cards were used together with a three digit card which corresponded to actual samples of cheese, provided to incorporate tasting within the conjoint analysis. These analyses were followed by a blind tasting of the samples. The results showed that the absence of tasting overestimated the importance of price and fat level. However, the inclusion of tasting as an extra attribute might influence the results of the conjoint analysis. The authors indicate that integrating tasting as a presentation method demands either a small set of samples, or data collection over several sessions. Thus, despite the remarks on the experimental design, the combination of a conjoint analysis with and without tasting gives an idea as to the influence of tasting.

A recent study, determined the influence of using tasting as a presentation method on the validity of conjoint analysis (Cerjak et al., 2010). The validity was measured using five criteria: face validity; convergent validity; internal validity; predictive validity; and subjective evaluation of the conjoint task. This study shows that conjoint analysis with tasting has higher face validity, although no other significant differences were observed for the other validity criteria. Furthermore, the authors state that when a conjoint analysis is performed with unfamiliar brands, the use of tasting gives better results than purely verbal conjoint analysis. However, when performing conjoint analysis with familiar brands, the use of tasting is unnecessary, as it has no influence on validity but does increase research complexity and costs.

7.6.3. Further developments in incorporating tasting within conjoint analysis

During the past decade, several studies have attempted to identify methods for combining tasting with conjoint analysis. Recently, Enneking, Neumann et al. (2007) undertook a research study on soft drinks, in which consumers simultaneously evaluated intrinsic and extrinsic product attributes within a choice-based conjoint analysis. Both verbal and real product tasting was used as stimuli. The authors indicate that, although this method is a valid instrument for the analysis of consumer segments, it is a demanding task for the consumer to evaluate both intrinsic and extrinsic attributes at the same time, particularly when pricing

is involved. However, the authors state that the combination of intrinsic and extrinsic attributes, not only measures the main effects but also the interaction between taste and other marketing-related attributes. Therefore, it helps to determine key drivers for product preference.

Haddad, Haddad et al. (2007) claim that the most reliable way to map the preference structures underlying purchase intent for foods is by including the tasting of products and a simultaneous modelling of the contributing effects of the products' other attributes and characteristics on consumers. The authors used focus groups to determine the most important attributes for the purchase of yoghurt. Sensory properties, fat level, price, method of production and presence of preservatives were the selected attributes for the conjoint analysis. The respondents received a sample of yoghurt and a card with verbal information. They were asked to taste the sample, read the card and then rate their purchase intent. Results again indicated that sensory properties are the driving force for purchase intent. Other attributes, such as extrinsic attributes, behavioural and demographic characteristics, are only modulating factors after sensory acceptance. It should be noted that, within this study, 144 combinations of the different attributes and levels were possible. Therefore, an orthogonal fractional factorial design with 16 profiles was used. Green and Srinivasan (1978) stated that orthogonal designs are robust enough to estimate the main effects of products' levels. Once again, it is demonstrated that including tasting in conjoint analysis requires a good model and experimental design.

7.6.4. Need for an effective experimental design

Recently, one group of researchers has developed a specific procedure to select the tasting samples for the conjoint analysis (Johansen et al., 2010b). They criticise that some '*studies might have used concrete products without focussing on specific sensory attributes, although these are often key factors for purchase*' (Johansen et al., 2010b). Consequently, they reason that the selection of the sensory attributes used in the conjoint analysis should be based on both focus groups and sensory analysis. In this way, the selected samples will span the overall sensory space. Meta-attributes can then be used as attributes within the conjoint analysis. In this study, sweetness and richness were used.

The proposed procedure outlines sample production, sensory profiling of the produced samples with a trained panel, identification of meta-attributes and selection of the representing samples. Afterwards, qualitative research is conducted, during which selection of the extrinsic attributes takes place. Finally, the conjoint analysis is performed, within which tasting of the samples is included. This method is specifically developed to keep the amount of samples for tasting low and feasible for the consumer. Moreover, it focuses on the sensory attributes that explain the variance between all commercially available samples. Their study on yoghurt confirmed the importance of sensory properties. In this study, the procedure starts with the production of 12 samples and ends by using 4 samples and 1 'dummy' sample within the conjoint analysis. Further study is needed to refine this last method. As it can

upgrade the use of conjoint analysis and sensory analysis within a company environment, it is likely that this issue will be the subject of further experiments in the future.

7.6.5. Limitations and opportunities

Although attempts have been made to incorporate tasting within conjoint analysis, several limitations inherent to either conjoint analysis or sensory analysis need to be considered. First, the small number of attributes that can be included within a conjoint analysis is a major point of criticism for the method. The need for a robust design for the experiment is vital. This is increasingly important when sensory characteristics are included within the conjoint analysis and more specifically when tasting is incorporated. Therefore, a precise selection of samples is critical to the design. The researcher needs to clearly state whether the study focuses on a concrete product or a specific product attribute. In the latter case, the necessary samples can be selected with the help of a trained panel and principal component analysis (Johansen et al., 2010b). However, for the selection of sensory characteristics, both sensory analysis and instrumental analysis are necessary to characterise the products in an objective way, as sensory analysis with a trained panel is highly influenced by their level of training, whereas instrumental data gives an unbiased view on differences.

Secondly, conjoint analysis requires that the researcher knows a priori the most critical non-sensory attributes and levels affecting consumer purchase. Depending on the researcher, these are selected by means of focus groups, quantitative data, open-ended questions, or other methods. A standardised selection is necessary to keep the amount of attributes and levels low.

Thirdly, several authors have indicated that the simultaneous evaluation of the intrinsic and extrinsic attributes of a product is a demanding task for respondents. The studies that have included extrinsic and intrinsic attributes within the conjoint analyses resulted in preferences that overestimated the influence of taste, as the respondents were too heavily focused on the tasting of the products. As a consequence, it is possible that these participants underestimated the influence of price or other extrinsic attributes. This limitation means that it is necessary to develop a method where the extrinsic and intrinsic attributes can be studied together.

Finally, a lack of motivation from consumers to participate can give unreliable data. This is particularly true when they are asked to taste a product. Therefore, an incentive might be a good way to encourage respondents to state their true preference.

7.7. Conclusions

As a method that originated in mathematical psychology, conjoint analysis has developed into a widely-used market research method across numerous sectors. The process of establishing and conducting a conjoint analysis continues to be a challenge and requires expertise on the part of the researcher and knowledge of the studied product. Despite its maturity, conjoint analysis continues to increase in depth and its areas of application are broadening.

Since research has proved that extrinsic and intrinsic attributes play a role in purchase intent or consumer preference for a food product, the trend has been set to model and refine a methodology to incorporate sensory characteristics within conjoint analysis. This can be achieved using stimuli that trigger different senses. Verbal and pictorial stimuli have proven to give valuable information when used in conjoint analysis. This review, however, focuses on the integration of tasting as the presentation method for sensory characteristics in conjoint analysis. This method can therefore be used to select the ideal product offering an optimal sensory quality for a specific target consumer group. Moreover, the review identifies the ways in which this has been done in the past, but also seeks to identify where these attempts were inadequate. Although much research has been done, there is still a need for a well-developed method. An extension of the method developed by Johansen et al. (2010b), with instrumental analysis, seems to be the most promising method for further development.

Furthermore, very little research has been undertaken to compare actual tasting of the product with verbal information on the taste of a product. Chapter 8 presents the experiment in which the aim was to study the influence of verbal information for the consumer on the sensory attributes of a product has a different effect on consumer purchase intent than when the consumer can taste the actual product during the conjoint analysis.

Further research in this area can help to improve the conjoint analysis as a marketing tool in the food industry. Although the main aim of conjoint analysis is to assist with product development, it is rarely used for this purpose. Research that combines sensory characteristics and conjoint analysis might help to identify ideal products for specific consumer segments. Development of such a method would be a valuable tool for the industry in terms of future innovation in order to survive in a competitive environment.

Chapter 8

Is taste the key driver for purchase intent of consumers? A conjoint analysis study

Adapted from:

De Pelsmaecker, S., Schouteten, J.J., Lagast, S., Dewettinck, K., Gellynck, X. Is taste the key driver for purchase intent of consumers? A conjoint analysis study. *In Food Quality and Preference (Under review)*

Abstract

The objective of this research was first to study the influence of using tasting as a stimulus in conjoint analysis. Second, the influence of a preliminary questionnaire to the conjoint task was studied. This questionnaire focused on the attitude towards chocolates.

A conjoint design was applied to examine the effects of intrinsic attributes (presence of sugar) and extrinsic attributes (brand and package size) on acceptability of chocolate and sugar reduced chocolate. Based on focus groups, the most important attributes and attribute levels were defined to use in the conjoint analysis. Two chocolates were produced following a standard procedure to ensure that presence of sugar was the only differing factor between both chocolates.

A total of 2096 respondents who were divided in four groups, completed the study. The results indicated that tasting has an influence on the importance ratings and the utilities for the overall population. Through clustering of the respondents, three clusters were identified which were recurrent for all groups and thus tasting the product did not influence the existence of these clusters. However, tasting did induce a shift from respondents from one cluster to another cluster. A combined method to identify the importance of sensory characteristics together with other extrinsic characteristics might help to compose ideal products for specific consumer segments. Development of such a method would be a valuable tool for the industry in terms of future innovation in order to survive in a competitive environment.

8.1. Introduction

In today's business, developing new products is a key objective for food companies. Mesias et al. (2013) stated that the current changes in social and consumption patterns give rise to new possibilities in food product development although there are challenges that producers need to overcome. For product innovations and reformulations to be successful, producers need to understand the influencing factors in food choice and identify what their impact is on purchase decision (Solheim and Lawless, 1996, De Pelsmaeker et al., 2015), given that food products are becoming even more complex due to consumers' demands (Chamorro et al., 2015). However not only attributes related to the product influence the purchase decision, but also expectations, individual cues, knowledge and beliefs about the food product and context effects (Shepherd and Stockley, 1987, Deliza and MacFie, 1996, Piqueras-Fiszman and Spence, 2015) as well as demographic and behavioural characteristics of consumers (Jaeger, 2006, Endrizzi et al., 2011). In general, consumers select or eliminate products by judging a few salient characteristics instead of processing information in a systematic way (Combris et al., 2009). Booth (2014) indicated in his review on the measurement of sensory and marketing influences on consumers' choices, that the best experiments in food science are those who create conditions of consumption which resembles a realistic situation.

Every food product is composed of intrinsic (internal) and extrinsic (external) attributes and a product formulation needs to comprise a good balance of both to be successful. Therefore, a methodology that incorporates sensory attributes and extrinsic attributes will help to indicate the drivers for acceptance of food products. It is important to understand the interplay of intrinsic and extrinsic attributes in order to optimize both during product development.

Many studies have focused on either extrinsic or intrinsic attributes. Grünert (2003b) states that for calorie-reduced products, health information is likely to affect choice at first purchase but that sensory dimensions and product experience are probably the main factors for repurchase. In addition, Cardello (1995, 1992) indicated that both sensory and hedonic expectations are important for consumer acceptance and satisfaction. Evidently, sensory attributes cannot be overlooked as they almost always have a significant weight in the final decision (Combris et al., 2009, Januszezewska et al., 2011). Nonetheless, focusing on sensory characteristics alone is also not sufficient to meet the requirements of today's fast moving market.

There are several methods to measure the value of specific characteristics of a product to consumers. De Pelsmaeker et al. (2013a) reviewed studies in which tasting of food products was used as a stimulus in conjoint analysis. Among the different methods that can be used, conjoint analysis is the most promising as it defines the relative importance of attributes which makes up for the structure of consumer preference (Mesías et al., 2013). Moreover, a conjoint analysis resembles the real choice situation and due to its design, it decreases the

risk of collecting socially accepted answers (Almli et al., 2015). This type of measurement focuses on responses to concept stimuli rather than actual concepts which not only helps to understand the subjective process for acceptance but is also a practical method for new product development (Moskowitz and Silcher, 2006). The method includes a set of techniques to measure the trade-offs consumers make among multi-attribute products such as food products (Asioli et al., 2014, Cox et al., 2007, Naes et al., 2010b).

Conjoint analysis is extensively used in marketing research to evaluate industrial products and services, and to determine food choice (Haddad et al., 2007, Asioli et al., 2014). The value of conjoint analysis is that most respondents do not have the time to intellectualize the test. They act on their intuition which favours the most important attributes (Raz et al., 2008). The raw data of the conjoint analysis can be used as input (posteriori) for segmentation of the respondents (Mesías et al., 2013). These consumers can also be clustered with consumer characteristics as input information (a priori clustering) before analysing the results of the conjoint analysis (Helgesen et al., 1998).

Previous studies which incorporated product tasting in a conjoint framework have focused on sensory quality (Solheim and Lawless, 1996, Helgesen et al., 1998, Haddad et al., 2007, Enneking et al., 2007). Johansen et al. (2010b) remarked that in all these studies, real products were used and thus they lacked the focus for a specific sensory property. As a result, it is difficult to identify the actual sensory drivers for liking.

This study will focus on chocolate with sugar or with a sugar replacer. Chocolate is a mass-consumed product in Belgium (Garrone et al., 2015). Moreover, this research was conducted in collaboration with Cacaolab, a spin-off of Ghent University. Here, the chocolates were being produced on a pilot scale to insure that presence of sugar is the only difference between the samples. This food characteristic is thus used as "design factor" in the conjoint analysis. Several authors already stressed the value of integrating sensory differences in conjoint analysis in the selected food products (Raz et al., 2008, Helgesen et al., 1998). Given that conjoint analysis is time-consuming and tedious, it is challenging to use in an experiment that requires the participant to taste. This problem can be overcome by using as less products as possible and setting up a well-defined experiment (Solheim and Lawless, 1996).

All of the above studies integrated either tasting before the conjoint task or as a stimulus in the conjoint part (De Pelsmaecker et al., 2013a). To the knowledge of the author, no study was published that conducted the experiment with and without tasting simultaneous in order to find differences in the stimuli presentation. In conclusion, little research has been undertaken to compare actual tasting of the product with verbal information on the taste of a product during the same experiment. Therefore, this research is conducted to identify whether the influence of verbal information for the consumer on the sensory attributes of a product has a different effect on consumer purchase intent than when the consumer can taste the actual product during the conjoint analysis (Hoppert et al., 2012).

A second novelty of this study is that it studies the effect of answering an attitudinal questionnaire prior to the conjoint task on the results. It has been argued that filling in a questionnaire as a pre-treatment affects the results of the final treatment. Most conjoint studies were set up in a way that the experimental part was followed by questions on purchase motives/patterns (Enneking et al., 2007) and attitudes (Asioli et al., 2014). Naes et al. (2010b) showed methodologies to segment respondents by using a type of cluster analyses on this data. This is particularly interesting to understand not only the overall or individual drivers for liking but how this can be related to attitudes or personal characteristics. Therefore it is suggested that in case of a high amount of respondents, consumers can be clustered first and that importance of attributes and levels can be determined in a second step (Naes et al., 2010b). This can also help when going beyond what is measured by conjoint analysis namely buying intent but also take into account behaviour.

This study used the attitude to chocolate questionnaire (ACQ) as pre-treatment questionnaire. Benton et al. (1998) developed this questionnaire to segment consumers based on their craving, guilty feeling and functional approach towards chocolate. This questionnaire was validated (Müller et al., 2008) and used in several scientific studies (Fletcher et al., 2007, Cramer and Hartleib, 2001). Completing this questionnaire can alter the mind-set of the respondents. Contrary to the respondents who did not fill in the ACQ, these consumers are forced to reflect on their attitude towards chocolate which can influence the trade-off they need to make in the conjoint analysis. Next to analysing the difference in results due to this preliminary treatment, the consumers are clustered and possible differences in trade-off between these clusters are also identified.

The objective of this paper was first to study the influence of using tasting as a stimulus in conjoint analysis. Second, the influence of a preliminary attitudinal questionnaire to the conjoint study was studied. To achieve these goals, a two-step method was followed: (i) a qualitative step and (ii) a quantitative step. The qualitative step aimed to determine which attributes and levels are imperative in the decision-making process when choosing chocolate. In the quantitative step, the conjoint analysis was applied to identify the importance of the different levels of selected attributes and the preference for the selected attribute-levels. Prior to the conjoint test, the quantitative step also included a socio-demographic and behavioural questionnaire. Part of the respondents also completed an attitudinal questionnaire prior to the conjoint test.

Chapter 7 already presented an overview of the design, the method of data collection and the analysis of the data.

8.2. Qualitative research

8.2.1. Methodology

When constructing a conjoint method, it is critical to select the most relevant attributes and attribute levels to include in the analysis. This qualitative step aims to identify the concept from a consumers' point of view and thus integrate the consumer's voice in the development of the 'ideal' product. Two focus group interviews were conducted in the meeting rooms in the Faculty of Bioscience Engineering at Ghent University.

The objective of this focus group was to gain insight in the most important extrinsic and intrinsic characteristics regarding chocolate and thus to identify those that have the greatest influence on choice decision. Every focus group consisted of 7-8 people. A total of 15 persons participated (10 females and 5 males) which are all familiar with qualitative research. All of them were frequent (more than once a week) chocolate consumers.

Each focus group lasted approximately 1 hour, was audio tape-recorded and later transcribed. During these focus groups, the moderator used an interview guide which was constructed and revised by two other researchers not familiar with the experiment (Appendix II). This guideline was constructed along the lines as the one used in the study of Di Monaco et al. (2007).

Each focus group started with an introduction in which the scope was explained. A warm – up exercise was used to involve every participant in the conversation. Here, they needed to introduce themselves briefly after which a discussion took place on their fundamental needs and motivations to buy and consume chocolate and on how they would describe their own behaviour towards chocolate. To find the most important and possible latent characteristics, a three step method was used.

First the participants needed to image their perfect piece of chocolate and write down the characteristics of this ideal product. The moderator encouraged the participants to think of both intrinsic and extrinsic attributes. Nevertheless, most of the given characteristics were sensory related (e.g. not too sweet, bitter, no milk chocolate, not too soft ...). The respondents were asked to orally present to the group one by one what they had written down. They were allowed to add characteristics to their list during these short presentations.

Second, the participants were presented with two chocolates monadically. The chocolates were presented in their package. The moderator explained that they could handle, smell and eat the chocolate. Afterwards, everyone was asked to rate how close each chocolate resembled the imaginary perfect chocolate from the first step. Moreover they had to indicate why these chocolates differed or resembled their perfect chocolate.

Third, they were asked to draft a final top five of characteristics that drives them to buy chocolate. This three-step method was used to retrieve the most important characteristics for consumers when selecting a food product.

8.2.2. Results of the qualitative research

The focus groups showed that sweetness (e.g. not too sweet, real cocoa flavour, no milk chocolate...), brand and package size (e.g. not too much in one piece, several pieces ...) were important. Some respondents indicated that price was an important factor however others stated that price did not really matter and that they preferred a good quality chocolate even if this meant they had to pay a higher price. Enneking et al. (2007) argued that a simultaneous evaluation of intrinsic and extrinsic product attributes is demanding for the respondent and thus difficult to match with pricing research. The researchers therefore decided not to incorporate price as an attribute in the conjoint study.

Next to sweetness, several other sensory aspects were also given as possible influencers. However, this study will focus on altering only one sensory characteristic in order to keep the amount of samples limited and the design simple. Therefore, it was decided to work with the attributes taste (altering sweetness), brand and package size.

8.3. Quantitative research

8.3.1. Experimental design

In this study, adaptive conjoint analysis (ACA) was used (Johnson, 1987). ACA consists of two tasks namely a self-explicated task in which the respondent rates the desirability and the importance of the attributes and a second task that comprises an evaluation of partial profiles, two at a time (Green et al., 1991). In this way, each respondent can select the attributes that they think are relevant for the concept and discard the rest of the attributes.

Several studies indicate that ACA is widely used in Europe (Wittink et al., 1994) and the US (Green et al., 1991). Almli et al. (2015) stated that the conjoint task can be boring or annoying for the respondents as it sometimes consists of nearly identical screens with nearly identical tasks. By using ACA, this problem is tackled as it consists of four steps in which respondents have to rate, indicate the importance and choose between products. The final step is a calibration step to examine if the respondent was truthful and not just clicking through the conjoint test. An R^2 is calculated based on this calibration step which can indicate if there is an issue with the utility estimation. The respondents may have not completed all tasks, leaving too little information to estimate, or their calibration answers do not agree with the answers from the pairs section. Respondents with a low R^2 may need to be removed from estimation entirely.

This set-up makes ACA capable to estimate individual preferences for a set of attributes while the task remains manageable for the respondents (Hoppert et al., 2012).

The objectives of this method are as follows:

- to compare the results of a conjoint analysis in which taste is described in a textual stimuli and a conjoint analysis in which tasting is used as an actual stimuli.
- to measure the impact of an attitudinal questionnaire preceding a conjoint analysis test.

The experimental design is set-up in such a way that consumers are randomly divided in four groups (Figure 8. 1). The following four groups are defined:

- Group 1 (G1): Textual description of the taste and no ACQ prior to the conjoint task
- Group 2 (G2): Textual description of the taste and ACQ prior to the conjoint task
- Group 3 (G3): Tasting of the samples and no ACQ prior to the conjoint task
- Group 4 (G4): Tasting of the samples and ACQ prior to the conjoint task

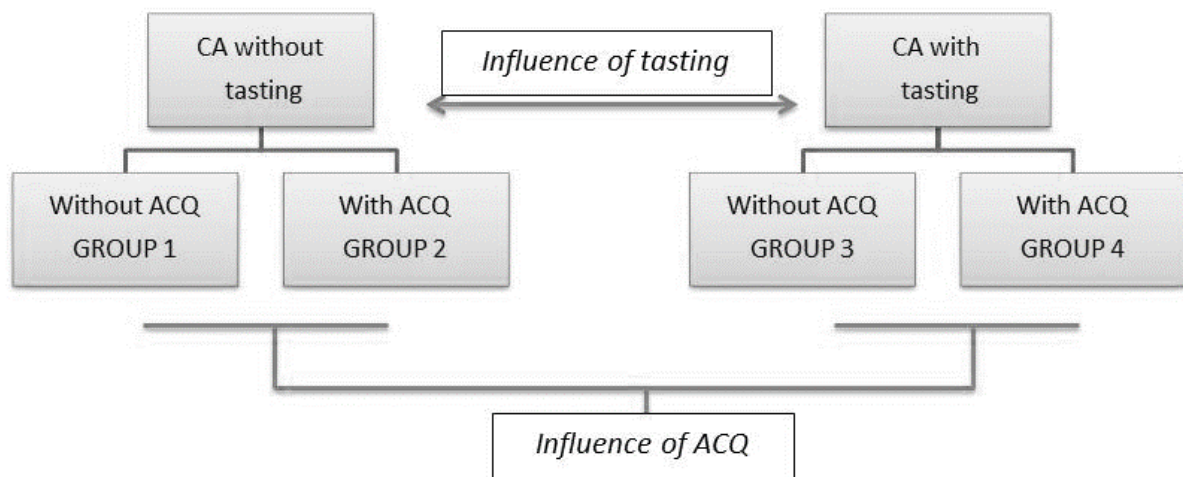


Figure 8. 1: Experimental design of the conjoint study with presentation of the different groups used

8.3.2. Design of conjoint experiment

Based on the qualitative research, taste, brand and package size were chosen as attributes for the conjoint analysis. In order to keep the task simple, two levels were assigned to each attribute. Conjoint analysis has been criticized in the past as being too complex to design, to be time-consuming and costly to carry out (Almli et al., 2015). Moskowitz & Silcher (2006) state that there should be no more than 4-5 items for every concept. A higher number would make the task fatiguing, difficult to read, give useless data and decrease the external validity of the conjoint results (Vriens, 1995). For brand, premium brand and private label were the chosen levels as most of the Belgium chocolates can be divided in these two groups. The levels for package size were bars of chocolate or tablet of chocolate. These levels were mentioned most frequently by the participants of the focus groups. They formulated it as '*I normally eat a complete bar of chocolate*'.

Finally, the most difficult task was to define the levels for the taste (levels of sweetness) of the chocolate. It was decided not to make the obvious choice to select a milk and dark chocolate as these are too different from each other to draw conclusions on sensory difference (Cardello et al., 2012). Johansen et al. (2010b) developed a procedure to select the samples which involves focus groups and sensory analysis. The final goal of this procedure is to span the overall sensory space with the samples that are included in the conjoint analysis. They also stated that some studies use products without focusing on a specific product attribute although it is often one specific attribute that influences the consumer to buy a product. De Pelsmaeker et al. (2013a) stated that it is critical for the set-up of a robust design to indicate a focus on a specific product or product attribute which leads to a precise selection of sample. Within the current study, the focus is on the chocolate produced with sugar or sugar-replacer. Stevia was chosen as sugar replacer. As suggested by Vickers (1993) the number of samples was kept low. It was decided to produce two dark chocolates specifically for this task to ensure that only one factor changed. Moreover, understanding the role of

taste in consumer's preference for sugar reduced food products can have major implications for both marketers and researchers in the food industry.

8.3.3. Design of the questionnaire

The conjoint analysis was incorporated in a questionnaire which consisted of three (G1 and G3) or four (G2 and G4) parts depending on the experiment treatment.

The *first* part consisted of questions regarding the purchasing behaviour of the consumers. Here the consumers indicated which chocolate they prefer, if they buy chocolate, for whom they buy chocolate and how many times they buy chocolate.

The conjoint analysis was the *second* part of the questionnaire. As it was an adaptive conjoint design, it included several steps. In a first step, every consumer needed to rate the levels of every attribute in the conjoint analysis. In the second step, every respondent had to indicate how important they rated one level over another as part of a product. In the third part, the consumers were presented with two pairs of product descriptions. For every presented pair, the consumers needed to indicate their preference for one product over another. The final set of questions consisted of three presentations of a product that the consumers had to rate from 0 to 100 with 0 meaning 'absolutely will not buy' and 100 'will definitely buy'. This last step was a calibration to ensure that the former answers of the consumers really represented their choice. The first product was assembled as such that it presented the most preferred attribute-levels. Therefore the first sample should be rated as close to 100. The second presentation contained attribute levels that were the least preferred. Therefore this sample should be rated close to 0. The final sample was constructed to present a product that would get a score of around 50.

The two groups that did not have to taste the chocolate received a verbal description of the two chocolate samples. The other two groups who had to taste the chocolates received the two chocolates at the beginning of the test. Each chocolate was coded with a three-digit code and was served on a plastic plate. The respondents were instructed not to taste the chocolates before indicated in the test and only when the three digit code was shown during the test. These three digit codes were thus used as presentation stimulus in the conjoint analysis.

The *third* part consisted of socio-demographic questions on gender, age, length, weight and the question if they watch their weight.

As indicated in Figure 8. 1 only two groups included the ACQ prior to the conjoint method (G2 and G4). The ACQ traditionally consists of 24 items (Benton et al., 1998) although only 16 items were included in this experiment. Previous studies indicated that a long questionnaire enhanced the fatigue with respondents. Therefore, only few items from the ACQ were selected instead of using the complete questionnaire since the objective is to study the influence of completing the ACQ and not the answers on the ACQ, the analysis of the results of previous studies (submitted not published) which included the complete ACQ were used

to make a selection (Table 8. 1). Item 6, 7, 8, 9, 10, 11, 18, 19 and 24 were not selected because these items were not loading on one specific factor or factors that were not included in the original study made by Benton et al. (1998). These items were used for the clustering of the consumers. All items were rated on a 7-point hedonic scale from "Totally disagree" to "Totally agree" with the preceding question "To what extend do you agree with the following statements?".

Table 8. 1: Overview of the selected items of the Attitude to Chocolate Questionnaire (based on data from Chapter 3 and 4)

ACQ item	Belgium (n=448)	Hungary (n=400)	France (n=36)	Belgium (n=18)
1 The thought of chocolate preys on my mind	Craving	/	Craving	Craving
2 I feel unhealthy after eating chocolate	Guilt	Guilt	Guilt	Guilt
3 I look at calories when eating chocolate	Factor 4	Guilt	Factor 4	/
4 I feel in control after not eating chocolate	Factor 4	Factor 4	Factor 4	Factor 5
5 Only chocolate satisfies my craving	Craving	/	Craving	Craving
6 I eat chocolate even when I do not want to	/	/	/	/
7 I eat chocolate to keep my energy level up	Functional	Functional	/	/
8 I eat more chocolate in winter	Functional	Craving	/	Factor 5
9 When I shop I often end up buying chocolate	Craving	Craving	Craving	Craving
10 I feel depressed and regret it when eating chocolate	/	Guilt	Guilt	/
11 I eat when I am bored	/	/	Craving	/
12 I like to indulge in chocolate	Craving	Craving	/	Factor 5
13 Eating chocolate cheers me up	Craving	Craving	/	Factor 5
14 The desire for chocolate is often overpowering	Craving	Craving	Craving	Craving
15 I feel unattractive after eating chocolate	Guilt	Guilt	Guilt	Guilt
16 I feel sick after eating chocolate	Guilt	Guilt	Guilt	/
17 I eat chocolate as a reward	Craving	Craving	Craving	/
18 I am often on a diet	Factor 4	Guilt	Factor 4	Guilt
19 The thought of chocolate distracts	Craving	/	Craving	/
20 I often want chocolate during the afternoon	Craving	Craving	Craving	Craving
21 Chocolate is high in fat	Factor 4	Factor 4	Guilt	/
22 I feel dissatisfied after eating chocolate	Guilt	Guilt	Guilt	/
23 I feel guilty after eating chocolate	/	Guilt	Guilt	Guilt
24 I only eat chocolate when I am hungry	Functional	Functional	/	/

8.3.4. Chocolate samples

In this study it was required to prepare samples on pilot scale and not use samples which are already on the market. Although this might be a deviation of mimicking a realistic situation, it was necessary to avoid bias for brand or package size. A standard procedure to produce dark chocolate was used. The alternative chocolate with sugar replacer Stevia was produced within the framework of another doctoral research at Cacaolab of UGent (Aidoo, 2015). The characterisation of these chocolates is presented in the published work of Aidoo, Afoakwa and Dewettinck (2015).

8.3.5. Respondents

The study was conducted at a public 10-day fair. Visitors of the fair were asked to participate in a consumer test on chocolate. This was a convenience sampling although there were two selection criteria: not allergic to chocolate and frequent (more than once a week) chocolate consumer. Further, the participants were informed that they were randomly assigned to a booth as every booth had a different type of the questionnaire. The respondents were informed that there was a 50 % chance that they had to taste chocolates during the test. As the questionnaire was rather long, it was important to use an incentive to motivate the respondents (De Pelsmaecker et al., 2013a). Therefore, all respondents were promised an extra piece of chocolate after completing the questionnaire as incentive. Moreover, they were also informed that they could receive more information on the scientific work after the study. This is also known to be a motivator for respondents as they feel to contribute to something and they are often happy to be asked to give their preference (Combris et al., 2009).

8.3.6. Data analysis

The conjoint data was collected with the Sawtooth Software. The Sawtooth Software calculates the raw utilities or values for the attribute levels which can be downloaded together with all the socio-demographic and behaviour data to an Excel-file. These raw utilities were zero-centred by subtracting the mean of the attribute levels from the raw utilities. Further, if utilities from different questionnaires (G1 to G4) need to be compared, these zero centred utilities need to be rescaled to make sure that everyone is on the same scale (i.e. that a utility value of 2 has the same meaning for all respondents) and thus to normalize the scale across the respondents, so that some respondents do not get a bigger effect on final results than others. Therefore, the zero-centred diffs rescaling method was used. For each attribute, the range of the utilities is calculated. Then a rescaling ratio is calculated by multiplying the amount of attributes with 100 and dividing it by the sum of all the utility ranges of that respondent. Finally the zero-centred utilities are multiplied with this rescaling ratio. The utilities mean the same, but zero-centred diffs are just bigger in magnitude. Rescaled utilities (such as zero-centred diffs) should be used when making comparisons across respondents (e.g. on average utility of Brand A or cluster analysis).

The importance ratings are calculated as presented by Raz et al. (2008). For the utilities $U_{i,j}$ (level j and attribute i), the importance I_i for the attribute i is calculated as follows:

$$I_i = \frac{\Delta U_{ij}}{\sum_{i=1}^n \Delta U_{ij}}$$

where U_{ij} is the range of the utilities for the attribute and $\sum_{i=1}^n \Delta U_{ij}$ the range of the utilities for n attributes. ANOVA and post-hoc test (Bonferroni) were used to find significant differences between the utilities and the importance rating due to the tasting of the chocolates or completing the ACQ prior to the conjoint test.

Further a cluster analysis was conducted to identify consumer segments with similar preferences for product attributes. The rescaled utilities were used as input for the cluster analysis. Previous research has used this type of clustering to distinguish groups with similar patterns for the utilities (Mesías et al., 2013, Carneiro et al., 2005, Lee et al., 2007, Haddad et al., 2007). Similar to Mesías et al. (2013) a hierarchical clustering procedure was performed to determine the number of clusters that is most fitting by using the squared Euclidean distance as distance measure and Ward clustering method. An ANOVA was used to check if the identified segments differed significantly from each other in terms of utility variables generated by the conjoint analysis ($p < 0.05$). It was decided on three clusters for every group. A K-means clustering was conducted to retrieve the final cluster centres. Crosstabs were used to identify the socio-demographic characteristics of the different clusters. Factor analysis was conducted on the 16 items of the ACQ. Construct reliability of the two-factor solution of the ACQ was tested by Cronbach's alpha. An identical clustering method as described above was used for the a priori segmentation of the respondents. All the statistical analyses were conducted in SPSS Statistics 21 (SPSS Inc., Chicago, IL).

8.4. Results

8.4.1. Rate of completed questionnaires

2407 consumers participated in the conjoint study conducted at a 10-day fair. A total of 2096 completed the study what resulted in useful data from 1570 respondents. Table 8. 2 presents the completed, useful and deleted data. Consumer data was deleted based on the R^2 calculated in the Sawtooth Software. This R^2 presents how much the utilities predict the actual choice of the respondents and thus indicates if there is an issue with the utility estimation. The respondents may have not completed all tasks, leaving too little information to estimate, or their calibration answers do not agree with the answers from the pairs section. The percentage of data which was not accountable is higher for the groups that did not have to taste chocolate during the conjoint test. The amount of useful data from the two groups that tasted the chocolate was almost 5 % higher.

Table 8. 2: Overview completed and usable data after data clearing obtained from the conjoint study

	Completed	Useful	Deleted	% Deleted
Group 1	555	403	152	27.39
Group 2	522	377	145	27.78
Group 3	548	427	121	22.08
Group 4	471	363	108	22.93

8.4.2. Sample description: Socio- demographic characteristics

Table 8. 3 presents the socio-demographic characteristics of the four groups. All four groups contained more females than males. In terms of age, all ages were represented in the study. In every group around 2/3 of the respondents indicated that they watch their weight. White chocolate was the least preferred type of chocolate in all the groups whereas the preference for milk and dark chocolates were very similar. The spread in the answers on the question 'how often do you buy chocolate' is also similar across the four groups.

8.4.3. Difference due to tasting of the chocolate sample

To identify if the actual tasting of the chocolate has an influence, the importance of the different attributes is calculated for every group (Figure 8. 2). The importance ratings present the weight of each attribute in consumers' appreciation and in concept appropriateness (Raz et al., 2008).

For G1 and G2, taste and brand are almost equally important and package size less important. When including tasting as a stimulus (G3 and G4), the importance value for the attribute taste almost doubles, whereas the importance value of brand decreases by half. A significant difference is found between the importance rating for G1 and G2 on the one hand side and G3 and G4 on the other hand for taste ($p < 0.001$) and brand ($p < 0.001$). For package size, no significant difference is found between G1 and G2. A significant difference is found between G1 and G3 ($p = 0.018$) and G1 and G4 ($p < 0.001$). The importance of G2 is significantly different

from G₄ ($p < 0.001$). The importance of package size is not significantly different for G₃ and G₄.

Table 8. 3: Socio-demographic characteristics (in per cent) of the respondents in the conjoint study

	Group 1 (N = 403)	Group 2 (N = 377)	Group 3 (N = 427)	Group 4 (N = 363)
Gender				
Male	39.5	32.1	34.9	40.8
Female	60.5	67.9	65.1	59.2
Age				
< 18	8.2	5.8	7.0	7.4
18-25	20.3	21.0	21.8	19.6
26-35	9.2	9.0	13.6	11.3
36-45	12.2	11.7	10.8	13.5
46-55	19.4	16.7	14.3	19.3
56-65	20.3	20.2	22.5	17.4
66-75	7.9	13.0	8.2	10.2
> 75	2.5	2.7	1.9	1.4
Watch your weight?				
Yes	64.0	65.0	64.4	59.8
No	36.0	35.0	35.6	40.2
Preferred chocolate				
White	11.4	13.5	8.9	8.0
Milk	43.9	37.4	41.9	48.2
Dark	44.4	48.8	48.9	43.8
None	0.2	0.3	0.2	0.0
How often do you buy chocolate?				
Every day	4.7	5.3	4.4	5.2
2-3 times a week	8.2	8.8	7.7	11.3
once a week	29.8	31.8	28.1	30.0
2-3 times a month	23.8	22.3	24.6	24.2
once a month	23.6	21.5	24.6	21.2
a few times a year	9.2	9.8	10.3	7.2
less than a few times a year	0.7	0.5	0.2	0.8

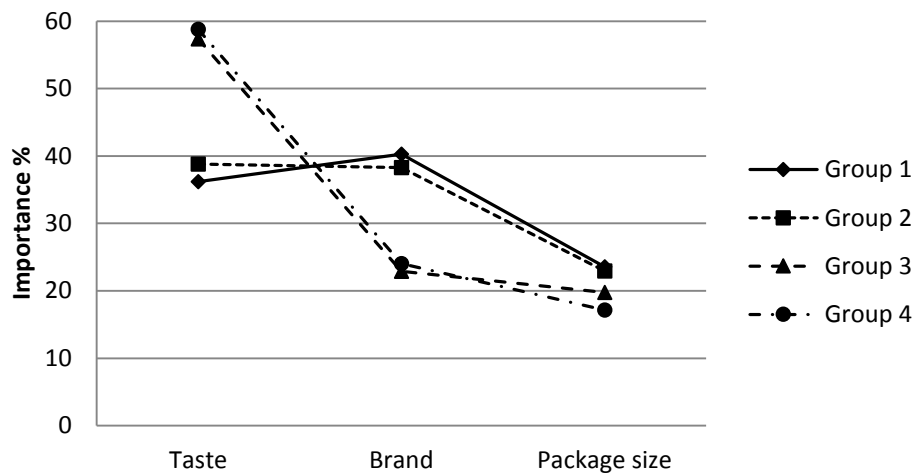


Figure 8. 2: The importance of chocolate attributes used in the conjoint study for the different respondent groups

Table 8. 4 presents the utilities allocated to each level of the attributes considered in the study. The value of the utility of each level indicates whether the presence of that level of the attribute adds (positive sign) or subtracts (negative sign) that amount of the utility to or from the product preference. Conjoint utilities are numeric values and are scaled to an arbitrary additive constant within each attribute (Orme, 2010d). It is possible to add a constant to the utilities for all levels of an attribute or to all attribute levels in the study, and it would not change our interpretation of the findings. Here, the utilities are scaled to sum to zero within each attribute.

Similar as for the importance, the differences between the conjoint analyses without and with tasting are clear. There is an agreement among the groups that sugar is preferable over sugar replacer in their selection of chocolate. However, the positive utility provided by the level 'sugar' is more pronounced when the respondents had to taste the different chocolates. The average utilities for G1 and G2 are significantly different from those of G3 and G4 for both sugar and sugar replacer.

Respondents indicate that for chocolate, they also prefer a premium brand instead of private label chocolate. In the two groups that did not taste the chocolate, the positive utility is very distinct whereas this impact decreases for the groups that tasted the chocolates. The average utilities for G1 and G2 are significantly different from those of G3 and G4 for both levels of the attribute brand.

The added value of specific package size is small. In G1 and G3, the respondents indicated that tablet size was a positive utility whereas in G2 and G4 the bar size is positive. The value of the utilities is low therefore, if a product is available in the least preferred package size, this will not decrease the acceptance of the consumer as much as the levels of brand and taste. No significant differences were found among the four groups for the average utilities of the package size levels.

These attribute levels indicate that the optimum combination for chocolate consumers is still a chocolate with sugar and from a premium brand. The package size is less important and the range between the utility levels is rather narrow. Tasting of the chocolate increases the range for the utility values of the taste attributes and decreases the range for the brand attributes. This shows again the impact that taste has on the preference of consumers.

Table 8. 4: Average utilities of all attributes levels in all respondent groups

		Group 1	Group 2	Group 3	Group 4
Taste	Sugar	11.52 ^a	14.26 ^a	47.28 ^b	49.57 ^b
	Sugar replacer	-11.52 ^a	-14.26 ^a	-47.28 ^b	-49.57 ^b
Brand	Premium brand	46.70 ^a	47.99 ^a	20.37 ^b	24.38 ^b
	Private label	-46.70 ^a	-47.99 ^a	-20.37 ^b	-24.38 ^b
Package size	One bar	-2.14 ^a	0.43 ^a	-1.07 ^a	0.95 ^a
	Tablet	2.14 ^a	-0.43 ^a	1.07 ^a	-0.95 ^a

^{a,b}, utilities within the same row with different letters are significantly different

8.4.4. Clustering

Utilities as presented in Table 8. 4 can hide behaviour patterns among respondents with similar preferences. A cluster analysis was conducted to classify the consumers into homogeneous groups based on their individual utilities.

8.4.4.1. Conjoint analyses without tasting as a stimuli

A three cluster solution was chosen in accordance with the size of the segments and based on the high significant differences (Table 8. 5).

Table 8. 6 gives the detailed socio-demographic characteristics and chocolate consumption of the clusters.

Group 1

Cluster 1 comprises one third of the consumers in group 1. This cluster attaches the highest importance to taste and they prefer the chocolate with sugar. The importance values for brand and package size are similar. They prefer premium brand and one bar as attribute levels. Although no significant differences were found, this cluster comprises a little more men, respondents who prefer white chocolate and a little more frequent chocolate purchasers.

The second cluster, a little larger than cluster 1, groups respondents that attach the greatest importance to the attribute brand and the lowest to taste. Again the preference is highest for a premium brand with sugar chocolate. This group contains highest percentage of milk chocolate lovers.

The smallest group of consumers are grouped in cluster 3. These respondents have a very different profile than the other two clusters. They attach most importance to taste and least to brand. More interesting, they prefer the sugar replacer, a private label and a tablet of chocolate. The third group contains the oldest respondents from group 1 and of the

respondents clustered here, 73% indicates to watch their weight. Moreover, they have the highest preference for dark chocolate.

Group 2

This group had to fill in the ACO before starting with the conjoint test. Therefore, this might influence the respondents in their answers. The average utilities did not show any significant results, but by segmenting this group, underlying trends can be identified.

Cluster 1 is the smallest group of respondents. These respondents attach most importance to taste and prefer sugar replacers in chocolate. Further, the least important attribute is brand. Package size is also important and for this attribute they prefer the tablet size. This cluster is very similar to the third cluster of group 1. Also the socio-demographic characteristics are similar to that cluster of group 1 namely older respondents, dark chocolate lovers and people who watch their weight. This last characteristic is significantly different for the respondents in the clusters of group 2.

Cluster 2 comprises the most respondents of group 2. This group attaches the highest importance to taste and they prefer the chocolate with sugar. Brand and package size are almost equally important. They prefer premium brand and tablet as attribute levels. This cluster is similar to the first cluster of group 1. No specific socio-demographic characteristics are found to be different from the other two clusters.

Table 8. 5: Conjoint analysis results for each cluster in G1 and G2: importance of attributes and level utilities

		Group 1			Group 2		
		Cluster 1 (133)	Cluster 2 (168)	Cluster 3 (102)	Cluster 1 (90)	Cluster 2 (147)	Cluster 3 (140)
Taste	Sugar	77.09 ^a	8.27 ^b	-68.62 ^c	-73.46 ^a	80.19 ^b	1.43 ^c
	Sugar replacer	-77.09 ^a	-8.27 ^b	68.62 ^c	73.46 ^a	-80.19 ^b	-1.43 ^c
	Importance	51.39% ^a	17.88% ^b	46.48% ^a	49.45% ^a	53.46% ^a	16.52% ^b
Brand	Premium brand	28.32 ^a	91.02 ^b	-2.34 ^c	5.92 ^a	28.83 ^b	95.15 ^c
	Private label	-28.32 ^a	-91.02 ^b	2.34 ^c	-5.92 ^a	-28.83 ^b	-95.15 ^c
	Importance	26.17% ^a	60.68% ^b	24.98% ^a	19.58% ^a	25.72% ^b	63.43% ^c
Package size	One bar	2.35 ^a	-1.21 ^a	-9.50 ^a	-11.18 ^a	-3.79 ^a	12.32 ^b
	Tablet	-2.35 ^a	1.21 ^a	9.50 ^a	11.18 ^a	3.79 ^a	-12.32 ^b
	Importance	22.43% ^a	21.44% ^a	28.53% ^b	30.96% ^a	20.82% ^b	20.05% ^b

^{a,b,c} values within the same row within each group with different letters are significantly different

The third cluster groups respondents that attach the greatest importance to the attribute brand and the lowest to taste. These respondents prefer a premium brand and one bar as package size. The utility range between sugar and sugar replacer is low which indicates that these respondents have no specific preference for either of those options. This cluster comes close to the second cluster from group 1.

Table 8. 6: Description of clusters for G1 and G2 by socio-demographic characteristics and chocolate consumption (%)

		Group 1			Group 2		
		Cluster 1 (133)	Cluster 2 (168)	Cluster 3 (102)	Cluster 1 (90)	Cluster 2 (147)	Cluster 3 (140)
Gender	Male	42.1	38.1	38.2	36.7	33.3	27.9
	Female	57.9	61.9	61.8	63.3	66.7	72.1
Age	< 18	7.5	7.7	9.8	4.4	4.8	7.9
	18-25	19.5	20.8	20.6	14.4	19.7	26.4
	26-35	12.8	8.3	5.9	10.0	10.2	7.1
	36-45	10.5	14.3	10.8	10.0	12.9	11.4
	46-55	18.8	19.0	20.6	13.3	15.0	20.7
	56-65	19.5	18.5	24.5	28.9	21.1	13.6
	66-75	7.5	9.5	5.9	16.7	14.3	9.3
	> 75	3.8	1.8	2.0	2.2	2.0	3.6
Watch weight	Yes	59.4	61.9	73.5	80.0*	59.2*	61.4*
	No	40.6	38.1	26.5	20.0*	40.8*	38.6*
Preferred chocolate	White	16.5	8.3	9.8	11.1	12.9	15.7
	Milk	40.6	48.8	40.2	33.3	37.4	40.0
	Dark	42.9	42.9	49.0	55.6	49.7	43.6
	None	0.0	0.0	1.0	0.0	0.0	0.7
Often buy chocolate?	Every day	6.0	4.2	3.9	7.8	5.4	3.6
	2-3 times a week	7.5	8.9	7.8	14.4	6.8	7.1
	once a week	30.8	31.5	25.5	26.7	33.3	33.6
	2-3 times a month	30.1	20.8	20.6	20.0	23.8	22.1
	once a month	18.8	23.2	30.4	18.9	23.8	20.7
	a few times a year	6.8	10.1	10.8	11.1	6.8	12.1
	less than that	0.0	1.2	1.0	1.1	0.0	0.7

(* for significant differences with $p < 0.05$)

8.4.4.2. Conjoint analyses with tasting as a stimuli

For the conjoint analyses in which tasting was included as a stimuli, a three cluster solution was chosen in accordance with the size of the segments and based on the high significant differences (Table 8. 7).

Table 8. 8 gives the detailed socio-demographic characteristics and chocolate consumption of the clusters.

Group 3

Cluster 1 groups the highest amount of respondents. This cluster attaches the highest importance to taste and they prefer the chocolate with sugar. The importance values for brand and package size are similar. They prefer premium brand and tablet as attribute levels. This cluster comprises younger respondents, who prefer white or milk chocolate. For this last attribute, a significant difference exists between the respondents in the clusters. This cluster is similar to the first cluster of group 1 and the second cluster of group 2 although the

importance value for the taste has increased with more than 10% and the importance for brand and package size has decreased with 5% to 10%.

The second cluster, with the lowest amount of respondents, groups respondents that attach the greatest importance to the attribute brand and the lowest to taste even with tasting as a stimulus. This cluster is similar to the second cluster of group 1 and the third cluster of group 2. The importance of taste increased however with around 7% whereas the importance of brand decreased. No specific socio-demographic characteristics are found to be different from the other two clusters.

The respondents from cluster 3 have a distinct profile. They attach the highest importance at the taste and prefer the sugar replacer in the chocolate. The least important attribute to them is brand. This cluster is comparable to the third cluster of the group 1 and the first cluster of group 2. Here again, the importance of taste increased and that of brand decreased by including tasting as a stimuli. This third cluster contains the dark chocolate lovers.

Table 8. 7: Conjoint analysis results for each cluster of G3 and G4: importance of attributes and level utilities

		Group 3			Group 4		
		Cluster 1 (270)	Cluster 2 (69)	Cluster 3 (88)	Cluster 1 (222)	Cluster 2 (70)	Cluster 3 (71)
Taste	Sugar	100.78 ^a	1.50 ^b	-80.96 ^c	104.36 ^a	-89.80 ^b	15.65 ^c
	Sugar replacer	-100.78 ^a	-1.50 ^b	80.96 ^c	-104.36 ^a	89.80 ^b	-15.65 ^c
	Importance	67.19% ^a	22.69% ^b	54.34% ^c	69.57% ^a	59.87% ^b	23.94% ^c
Brand	Premium brand	11.04 ^a	71.66 ^b	8.79 ^a	11.48 ^a	8.96 ^a	79.89 ^b
	Private label	-11.04 ^a	-71.66 ^b	-8.79 ^a	-11.48 ^a	-8.96 ^a	-79.89 ^b
	Importance	17.50% ^a	48.52% ^b	19.35% ^a	15.46% ^a	21.28% ^b	53.66% ^c
Package size	One bar	-2.64 ^a	33.14 ^b	-23.08 ^c	-2.04 ^a	-0.02 ^{a,b}	11.25 ^b
	Tablet	2.64 ^a	-33.14 ^b	23.08 ^c	2.04 ^a	0.02 ^{a,b}	-11.25 ^b
	Importance	15.31% ^a	28.79% ^b	26.30% ^b	14.97% ^a	18.85% ^{a,b}	22.40% ^b

^{a,b,c} values within the same row within each group with different letters are significantly different

Group 4

Cluster 1 of group 4 is very similar to cluster 1 of group 3 for utilities and importance values but also for the socio-demographic characteristics. This cluster contains most of the respondents in group 4.

Cluster 2 is the group which comprises the respondents who prefer sugar replacers and care little about brand and package size. Similarities can be found with cluster 3 of group 3 although the respondents here value brand a little higher than package size. This group however also contains the highest percentage of dark chocolate lovers.

The third and final cluster is again similar to a cluster from the other group namely cluster 2 from group 3. These respondents value brand above all other attributes.

Table 8. 8: Description of clusters for G3 and G4 by socio-demographic characteristics and chocolate consumption (%)

		Group 3			Group 4		
		Cluster 1 (270)	Cluster 2 (69)	Cluster 3 (88)	Cluster 1 (222)	Cluster 2 (70)	Cluster 3 (71)
Gender	Male	33.7	36.2	37.5	36.5	51.4	43.7
	Female	66.3	63.8	62.5	63.5	48.6	56.3
Age	< 18	7.0	8.7	5.7	7.2	11.4	4.2
	18-25	23.7	21.7	15.9	21.6	17.1	15.5
	26-35	15.6	10.1	10.2	9.9	12.9	14.1
	36-45	9.3	10.1	15.9	17.6	7.1	7.0
	46-55	15.6	11.6	12.5	18.9	21.4	18.3
	56-65	20.4	30.4	22.7	16.2	11.4	26.8
	66-75	7.8	5.8	11.4	7.7	17.1	11.3
	> 75	0.7	1.4	5.7	0.9	1.4	2.8
Watch weight	Yes	61.9	72.5	65.9	57.7	64.3	62.0
	No	38.1	27.5	34.1	42.3	35.7	38.0
Preferred chocolate	White	9.3*	5.8*	10.2*	8.6	5.7	8.5
	Milk	47.4*	40.6*	26.1*	51.4	35.7	50.7
	Dark	43.0*	53.6*	63.6*	40.1	58.6	40.8
	None	0.4*	0.0*	0.0*	0.0	0.0	0.0
Often buy chocolate?	Every day	5.6	4.3	1.1	5.4	2.9	7.0
	2-3 times a week	7.0	13.0	5.7	9.5	12.9	15.5
	once a week	28.1	29.0	27.3	30.2	27.1	32.4
	2-3 times a month	23.7	24.6	27.3	26.1	24.3	18.3
	once a month	24.1	23.2	27.3	22.5	21.4	16.9
	a few times a year	11.1	5.8	11.4	6.3	10.0	7.0
	less than that	0.4	0.0	0.0	0.0	1.4	2.8

(* for significant differences with $p < 0.05$)

The description of the different cluster already indicated that they can be grouped in three similar segments (Table 8. 9). The first segment comprises the consumers that are loyal to the sugar containing chocolate, the traditional taste of chocolate. The brand and package size are less important. When using tasting as a stimulus, the importance of taste even increases and the other two attributes are less important. The second segment of consumers is driven by the brand of the chocolate in their preference for chocolate. They indicate that taste is less important and this is confirmed by the conjoint analyses in which taste was included as a stimulus. There was an increase in the importance of tasting but less than in segment 1. The third segment is the group of consumers that chooses the chocolate with the sugar replacer also when they taste the product. However, it can be noted as well that the amount of respondents in segment 2 and 3 are lower in the groups that used tasting as a stimuli. This indicates that tasting the product makes people transfer from one segment to another. This indicates the large influence of tasting on product preference.

Table 8. 9: Description of the three segments distributed over the different respondent groups

	Sugar taste driven (772)	Brand driven (448)	Sugar taste replacers (350)
Group 1	Cluster 1 (133)	Cluster 2 (168)	Cluster 3 (102)
Group 2	Cluster 2 (147)	Cluster 3 (140)	Cluster 1 (90)
Group 3	Cluster 1 (270)	Cluster 2 (69)	Cluster 3 (88)
Group 4	Cluster 1 (222)	Cluster 3 (71)	Cluster 2 (70)

8.4.5. Impact of ACQ

8.4.5.1. Influence of completing the ACQ on conjoint data

A second novelty of this research paper is the study of filling in the ACQ before conducting the conjoint analysis. Table 8. 4 indicates that there are no significant differences between G1 and G2 of which the questionnaire only differs in the absence or presence of the ACQ. The same result is found for G3 and G4. Therefore, it can be concluded that filling in an ACQ prior to the conjoint analysis does not affect the utilities or importance values.

8.4.5.2. Differences in factor values in the defined clusters

A factor analysis was conducted on the ACQ items in G2 and G4. This resulted in two clusters in each group namely 'craving' and 'guilt'. Table 8. 10 shows that the factor values only different for the guilt factor in G2. The respondents in cluster 2 (=sugar taste driven) reported a significant lower guilty feeling.

Table 8. 10: Mean factor values for the defined clusters in G2 and G4.

	Group 2			Group 4		
	Cluster 1 (90)	Cluster 1 (147)	Cluster 3 (140)	Cluster 1 (222)	Cluster 2 (70)	Cluster 3 (71)
Craving	3.50 ^a	3.73 ^a	3.83 ^a	3.78 ^a	3.64 ^a	3.76 ^a
Guilt	3.15 ^a	2.58 ^b	3.11 ^a	2.08 ^a	2.11 ^a	2.08 ^a

^{a,b,c} mean values within the same row within each group with different letters are significantly different

8.4.5.3. Clustering based on the ACQ

For both G2 and G4 clustering was conducted based on the two defined factors (a priori clustering). Table 8. 11 shows that no significant differences were found for the importance of the attributes or the utilities of the attribute levels. Therefore respondents, who are assigned to a specific cluster, do not have a different preference for chocolate product attributes. This would indicate that filling in an attitudinal questionnaire does not have an effect on the conjoint data.

Table 8. 11: Conjoint analysis results for each cluster of G2 and G4 after clustering on ACQ: importance of attributes and level utilities

		Group 2			Group 4		
		Cluster 1 (113)	Cluster 2 (157)	Cluster 3 (107)	Cluster 1 (222)	Cluster 2 (70)	Cluster 3 (71)
Taste	Craving	4.38 ^a	2.41 ^b	4.91 ^c	4.39 ^a	2.47 ^b	4.89 ^c
	Guilt	4.56 ^a	2.21 ^b	2.19 ^b	3.81 ^a	1.57 ^b	1.50 ^b
	Sugar	3.59 ^a	13.89 ^a	26.07 ^a	47.91 ^a	44.02 ^a	57.75 ^a
	Sugar replacer	-3.59 ^a	-13.89 ^a	-26.07 ^a	-47.91 ^a	-44.02 ^a	-57.75 ^a
Brand	Importance	33.84% ^a	41.49% ^a	40.03% ^a	56.87% ^a	58.67% ^a	60.26% ^a
	Premium brand	54.36 ^a	41.75 ^a	50.39 ^a	26.00 ^a	21.46 ^a	26.90 ^a
	Private label	-54.36 ^a	-41.75 ^a	-50.39 ^a	-26.00 ^a	-21.46 ^a	-26.90 ^a
	Importance	41.75% ^a	36.09% ^a	37.76% ^a	24.05% ^a	24.02% ^a	24.10% ^a
Package size	One bar	3.66 ^a	1.10 ^a	-3.98 ^a	3.79 ^a	3.85 ^a	-4.74 ^a
	Tablet	-3.66 ^a	-1.10 ^a	3.98 ^a	-3.79 ^a	-3.85 ^a	4.74 ^a
	Importance	24.41% ^a	22.42% ^a	22.22% ^a	19.08% ^a	17.30% ^a	15.63% ^a

^{a,b,c} values within the same row within each group with different letters are significantly different

8.5. Discussion

De Pelsmaecker et al. (2013a) identified in their review several limitations when tasting is incorporated as a presentation method for stimuli in conjoint analysis namely the amount of attributes need to be kept low, the most critical attributes and levels affecting consumer purchase need to be identified, the need to keep the task manageable for the respondents and keep them motivated. Further the complexity of the design and the costs can be limiting factors (De Pelsmaecker et al., 2013a, Cerjak et al., 2010). By limiting the attributes and levels, several of these critical points are covered. Further, the consumers were sampled at a fair and rewarded with pieces of chocolate to keep them motivated. De Pelsmaecker et al. (2013a) stated that including tasting could make the consumer assessment tiresome if a high amount of combinations exist. However, due to the experimental design, the consumer only needed to taste two samples throughout the conjoint analysis. Given that the differences in taste between both samples were clearly detectable, the respondent did not need to taste every time the stimuli was presented as taste memory could help to make the trade-off. Moreover, as the sensory stimuli were incorporated together with extrinsic attributes, there was no specific focus on the tasting of the products which could bias the answers (Vickers, 1993). The results of the amount of deleted data clearly indicate that introducing tasting as a presentation method does not make the task more difficult for the respondents. On the contrary, the respondents were more focused and engaged in the task than without tasting.

Before discussing the results of the conjoint analysis, it needs to be indicated that the attribute taste was used here as a meta-attribute (Johansen et al., 2010b). Therefore, it must be indicated that the presence of sugar or a sugar replacer is related to a number of correlated sensory attributes such as sweet flavour or bitter aftertaste due to the Stevia (Endrizzi et al., 2015, Zorn et al., 2014).

The qualitative analysis allows identifying the main attributes that drive consumer's preference. By presenting real products at the qualitative phase, the intrinsic attributes are gathered together with the extrinsic attributes. As in the method used by Raz et al. (2008), the focus is also directed to how the sensory attributes are expressed in the overall product concept. This makes it an ideal method to trace the most essential properties for a product under study. Therefore, this experiment does not follow the method of Johansen et al. (2010b) in which sample selection is a first step. This method is preferably used when working with commercial samples, when several prototypes are used or when mixtures of commercial and specifically produced samples are used. However, here the samples are selected after collecting the intrinsic attributes. The method applied here is fitting when researchers have the opportunity to define and produce the products to use in the experiment.

The originality of the paper is found in the identification of the influence of real taste perception during the conjoint analysis. Several studies already found that taste is important

for food market segmentation and product differentiation (Enneking et al., 2007, Poelman et al., 2008, Johansen et al., 2010b).

It was hypothesized by several studies that integrating sensory differences as factors can be of great value (Helgesen et al., 1998). Previous studies indicated that sensory properties and specifically taste have an overwhelming effect when consumers are confronted with the product and are a main driver for food choice (Garcia-Bailo et al., 2008, Hoppert et al., 2012). Moreover, when tasting was incorporated in the study design, purchase decisions were shaped primarily by the taste qualities of the products. Haddad et al. (2007) stated that mapping preference structures underlying purchase intent of foods is "*most reliably executed by including tasting of products and simultaneously modelling of the contributing effects of the products' other attributes and characteristics of the consumer*". This study confirms the strong impact of tasting a product in a conjoint analysis both on the importance rating but also on the utilities. The impact of tasting as a presentation stimulus is represented by the increase of importance rating for the attribute taste, and the broader range of the utilities between the taste levels.

The utilities indicate that sugar is the preferred level, over sugar replacer for the overall population. The results are in line with the findings from Grünert (2003a) which stated that sensory dimensions are primarily responsible in repurchase decisions as results indicated that the positive sensory impact of a higher sugar content is only partly equalized by the positive impact of a 'sugar-reduced' claim on the product. A previous study with sugar replacers in orange juices showed that respondents preferred sugar over the alternative sweetener when tasting the product (Enneking et al., 2007). Johansen et al. (2010b) found that sweetness had a positive effect on purchase probability for yoghurt samples in blind tasting. Nonetheless in their study, consumer acceptance increased by giving information on low sugar content. One would expect that as consumers become more aware of the high levels of sugar and fat they consume each day, reduction of the ingredients is appealing for consumers and increases acceptance (Helgesen et al., 1998, Hoppert et al., 2012). This is not confirmed as in this study only 22% of the viable results from respondents indicate that they would prefer a sugar replacer. Thus chocolate seems to be a food product for which consumers do not want to change in sugar level. Hoppert et al. (2012) indicated that policy makers are facilitating healthy food consumption as a step to decrease the growth in diet-related diseases. However, studies hinted that there may be a conflict between health and taste motives (Roininen and Tuorila, 1999, Tuorila and Cardello, 2002, Verbeke, 2006). This study indicates that respondents think of chocolate as a product in which they do not want to trade taste for healthy aspects. 'Brand effects' have been regarded as an interfering factor when conducting sensory analysis. However, the interaction between brand as an extrinsic factor and sensory attributes should be considered as vital for product success (Cerjak et al., 2010, Booth, 2014). Here the results indicate that the importance of brand decreases as tasting of the product is incorporated.

Clustering of the respondents was conducted as some studies identified segments of consumers who make product choices based solely on sensory cues, whereas other segments indicate extrinsic cues as more important (Didier and Lucie, 2008, Mueller and Szolnoki, 2010). In order to have useful data, Raz et al. (2008) indicated that a high number of respondents is necessary for the clustering to be relevant. After conducting cluster analysis, three clusters were identified. Every group contained one cluster in which respondents make their choice based on taste, one cluster that makes the choice based on brand and one cluster in which consumers prefer the chocolate with sugar replacer and the private label. This shows that clustering is vital to the understanding of the market. If the producers would make a chocolate based solely on the overall population results (sugar and premium brand), they would only fulfil the needs of part of the population. By clustering the population, three clearly defined groups could be identified, each demanding a product assembled with different attribute levels.

The importance rating and utilities show that integrating an attitudinal questionnaire before the conjoint task does not influence the outcome. Based on the a priori segmentation method defined by Naes et al. (2010b), it is shown that individuals with different attitudes do not have different preferences for product attributes. Therefore, it is hypothesized that the cause for purchase intent for Belgian consumers is not based on attitudes to chocolate but perhaps on food choice motives (Steptoe et al., 1995, Januszezewska et al., 2011). By clustering the respondents on results from a behavioural questionnaire, it is possible to not only measure buying intent through conjoint analysis but also to combine this with behavioural aspects.

As this research was exploratory, our study can be extended in several ways. A limitation of this study is the number of studied attributes. For example, more attributes and attribute levels can be included in the study. Due to the comparative nature of this experiment, the design was kept simple. It can be argued that it is too low to mimic a real situation, however this was not the aim of the study given that so many respondents needed to be reached (Raz et al., 2008). The key attributes that make up for product success are numerous and could not all be taken into account in this study. Future research with more attributes and a corresponding lower amount of respondents to keep the experiment manageable and within certain price limits should be conducted.

The hypothetical nature of the choices presented to the participants are a limitation to this study. Although consumers often try to rate or rank the samples as required, they often unconsciously manipulate their answers. In future studies, researchers can overcome this by making the selected choice or the most optimal choice available to the respondent (Alfnes et al., 2006, Lusk et al., 2008, Combris et al., 2009).

Further, the study can be conducted with other food products to measure the influence of taste or by expansion other sensory attributes in consumers' choice. This will also give data to compare the impact of influence between different products or product groups.

8.6. Conclusion

This research contributes to the growing body of literature on roles of intrinsic and extrinsic attributes on consumer preferences by using taste as an indicator for the influence of sensory characteristics. An integrated approach is necessary to get a better understanding of consumers' preference. To achieve this, experts from different disciplines need to collaborate to develop an experimental design which approaches real life situations without allowing more bias in the experiment. This study confirmed that a conjoint analysis which combines sensory quality and extrinsic attributes of the products can help to develop a holistic picture of purchase decisions and the underlying preference structure (Mesías et al., 2013). Moskowitz and Silcher (2006) already stated that conjoint analysis can be used to create totally new to the world combinations of product attributes and thus will lead to true consumer-driven co-creation and innovation. This is of key importance in the innovation driven economic environment of today.

The utilities can help to create the ideal product by combining several attribute levels. Therefore conjoint analysis is an important tool when defining marketing strategies as it helps marketing professionals to understand the relative importance of product attributes (Carneiro et al., 2005). Not only can existing products be altered to fit the need of consumers but it will also help to outline the process to develop novel products for different consumer segments (Malhotra, 1999). As conjoint analysis works with a concept and not a prototype, it can be included in the Stage-Gate® process as early as the stage in which the business case is build. Cooper (2008) indicated that in the next generation Stage-Gate® spiral developments can be built in. The author defines the second spiral as the 'full proposition concept test' at the stage of the business case. As conjoint analysis gives a representation of the proposed product, it will give a customer a feeling of what the product will be. If it is possible, as illustrated in chapter 7 and 8, to include tasting as a part of the conjoint analysis, this will provide valuable information for the go/kill decision at the following gate.

Chapter 9

General conclusions

In the previous parts and chapters, an in-depth discussion and conclusion of the study-specific findings was provided. This final chapter discusses and concludes on the findings in more general terms. Hereunder, answers to the research objectives and related research questions (9.1) are given, based on the results presented in the different research chapters. Then, a general discussion (9.2) presents a review of the conceptual framework and an overview of the current issues when implementing 'sensory analysis' in consumer-driven new product development. Next, the scientific contribution of this doctoral research is described together with the practical relevance of the research (9.3). The following section recognizes the limitations of this doctoral research (9.4). Based on these limitations and the findings from previous chapters, suggestions for future research are formulated (9.5).



9.1. Research objectives and research questions answered

The doctoral research addresses six research questions concerning the sensory evaluation of chocolate products and how this can be interlinked with process parameters, consumer behaviour and consumer-driven product development in order to increase the success of products.

In the following paragraphs the research questions are revisited in relation to the conceptual framework (Figure 9. 1). The boxes in Figure 9. 1 in bold are related to Part I, italic to Part II and underlined to Part III. Boxes that have several marks are related to different parts of the doctoral research.

Part I: Chocolate: A Sensory success story

Research objective 1: Identification of key sensory attributes of chocolate

The first part of this doctoral research focuses on the sensory characteristics of the chocolate products. What are the characteristics that drive consumption, which characteristics can be altered and how can they be measured? Understanding all these aspects will help the company to innovate in different ways (Moskowitz et al., 2006) and differentiate their products from those of the competitor (Thomson et al., 2010).

The first research question therefore asked:

RQ1: what are sensory attributes that consumers use to assess the quality of chocolate?

Understanding the sensory drivers which consumers relate to quality can create opportunities for product improvement or product development (Moskowitz and Hartmann, 2008). The results of chapter 2 confirm previous studies that consumers have a rather limited vocabulary to describe chocolate products (Thamke et al., 2009).

Consumers use similar sensory attributes to describe appearance and texture of white, milk and dark chocolates. However, consumers set out other different standards for these characteristics. For example hardness and snap need to be different in white, milk and dark chocolate. These descriptors for appearance and texture are related to the production parameters. Therefore, when developing new products, producers needs to take into account these intention differences. (Benner et al., 2003b) .

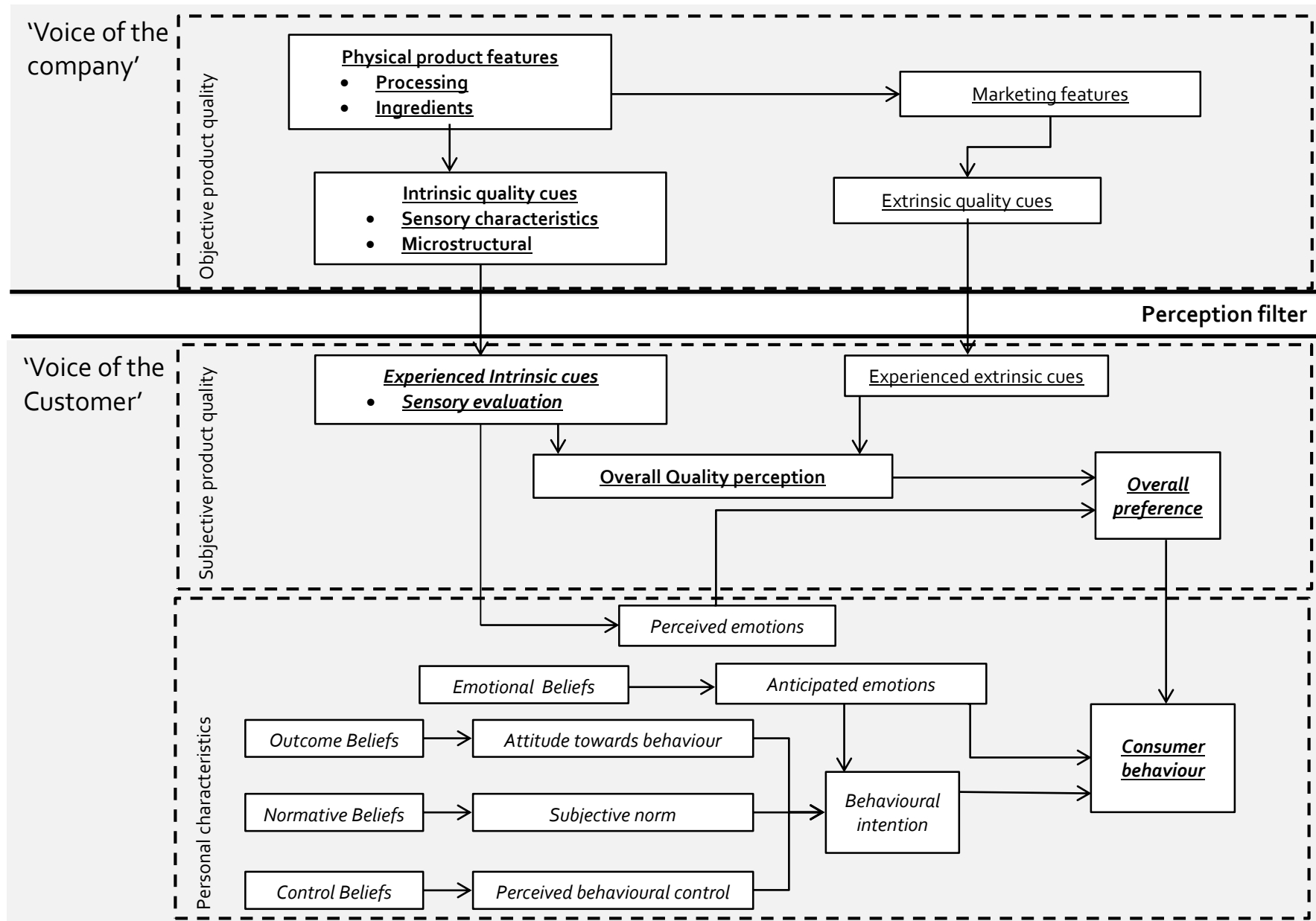


Figure 9. 1: Conceptual framework revisited

Moreover, the aroma and flavour profiles as assembled by the consumers are completely different for white, milk and dark chocolates. This indicates that flavour and aroma characteristics are certainly determined by the composition of the ingredients and the types of cocoa beans (Afoakwa et al., 2008a). In conclusion, in product development it is important to look at different flavours but also to differentiate the intensities of texture characteristics.

The second research question asks:

RQ2: How can sensory analysis contribute to characterise physical product features?

The studies conducted in chapter 3 all focused on different aspects of this research question. This research question can be answered by using and comparing the results of sensory analysis with humans (either trained panels or consumers) and instrumental analysis (Andrae-Nightingale et al., 2009, Jovanović and Pajin, 2002). Every study in this chapter clearly indicates that the chosen analysis is dependent on what a company wants to know. Roughly, this can be subdivided in problems or questions related either to the voice of the company such as what ingredients should be used, which process parameters should be chosen or to the voice of the customer such as defining the product acceptance (Benner et al., 2003b).

The first sub question is related to the voice of the company and was formulated as:

Is sensory or instrumental analysis the most appropriate method to characterise chocolate products? (RQ2a).

In this doctoral research, the conducted studies looked at product handling, threshold detection and drivers for innovation.

First, a trained panel always handles a complete product whereas a machine only evaluates pieces of product. This was illustrated with the colour measurements of bloomed filled chocolates. This difference in product handling can cause differences in results and might lead to missing valuable information necessary for product improvement.

This chapter also pointed out the existence of a gap between the results from the instrumental analysis and the sensory analyses both with trained and consumer panel. In the study on graininess, the results indicated that instrumental analysis was much more sensitive than the trained panel and the consumer panel. However, are the results of the instrumental analyses providing information on what the consumer is experiencing? Again, the importance of defining what you need to learn from the analysis is pointed out. Here, it was obvious that the instrumental analysis did not provide any information of the graininess detection by consumers. The results of the trained panel did however show that the threshold of consumer would be above 40µm.

However, the combination of different methods can provide extra useful information that can lead to innovation (Grunert et al., 2008). In the study on graininess, the results of the trained panel and consumer panel state that it might be possible to alter the overall accepted processing standard for particle size. First, the trained panel indicated that different particle

sizes do not lead to differences in other textural characteristics. Moreover, the trained panel and the explorative consumer test indicated that consumers could not identify differences below 40 μm . Therefore, the threshold at which consumers can detect graininess in the chocolate is most likely higher than this value. This study confirmed what Moskowitz et al. (1999) already indicated, that opportunities for innovation are found on the intersection of different methodologies. Changing the particle size will lead to a change in the processing conditions of the refining and conching process (Afoakwa et al., 2007). The economic result of this alteration can be calculated and is likely to be beneficial for the company.

This study also points out the added value of conducting discriminative analysis prior to descriptive analysis or consumer tests. Before conducting these tests, a researcher should confirm that there is an actual difference that can be detected by humans. Prior knowledge on product differences reduces the amount of samples that need to be analysed by a trained panel. This again decreases the resources that need to be invested in descriptive analyses. Moreover, products that do not differ from each other should not be used in consumer tests as the final data will be misleading and incorrect which again leads to a loss of resources.

In conclusion, both sensory analysis and instrumental analysis are useful in the characterisation of chocolate products. Depending on the question, one method can be preferred over the other. However, in many cases, the combination of both methods provides more and complementary information which results in a better understanding of the product. This can lead to several types of innovation and possibly reduce time and money in production or product development.

The second sub question is related to the aspect of consumer-driven product development and is thus related to the voice of the customer which is equally important in product development as the technological aspects of this product development (Linnemann et al., 2006, De Pelsmaeker et al., 2015):

Which insights does sensory analysis provide on product acceptance? (RQ2b)

The results in chapter 3 present how sensory analysis can provide insights in the positive and negative drivers of product acceptance and overall preference. In previous decades, books or manuals on sensory analysis indicated that consumer tests should be limited to preference and acceptance tests (Amerine et al., 1965, Meiselman, 1993, Sidel and Stone, 1993). These results were then correlated to data from the trained panel for better understanding of acceptance or preference. Nowadays, consumer tests use very specific methodologies (e.g. JAR-scale) are used to uncover more details of the product than solely the acceptance or preference (Jaeger et al., 2015, Rothman, 2007, Ares et al., 2015, Ares et al., 2014). These different techniques were developed so that more information could be retrieved from consumers without using a trained panel. This is most often related to the decrease in necessary financial resources but also to get faster results (Meiselman, 2013). However, it must be stressed that the data that is retrieved from consumers is always subjective while objective and more in-depth evaluations are still collected with a trained panel.

In this doctoral research, the JAR scale is used frequently as the results of this test can identify a hedonic optimum for a specific sensory attribute (Rothman, 2007). Understanding this hedonic optimum is necessary for product improvement (Tuorila, 1996). This was illustrated in the third study of chapter 3 dealing with texture attributes. After defining the hedonic optimum of an attribute, this can be translated in process parameters to obtain this optimum in the final product.

However, the study also captured a critical point when conclusions would be based solely on consumer tests. The advantage of a trained panel is that the evaluations are conducted by individuals who are familiar with the procedure, understand the wording and use the scale in a similar way (ASTM, 1992a, Stone and Sidel, 2004a). These aspects are absent in consumer tests. The studies in chapter 3 showed the importance of wording in the question. The interpretation of an attribute or a question can be different from consumer to consumer (Stone et al., 2009). As there are definitely some constraints to rely solely on consumer tests, the advantages and disadvantages of conducting complementary tests with a trained panel should be taken into account.

All studies conducted in Part I illustrate the complexity of chocolate products and the necessity of well-constructed research designs to gain more knowledge on the product. The complementarity of sensory and instrumental measurements can be of great value when trying to answer specific research questions. Moreover, it depicts that the results should be interpreted with an open mind and take into account possible bias. This bias, in particular for consumer tests, is often related to personal characteristics, which is the topic of Part II.

Part II: Influence of emotions on consumer behaviour

Research objective 2: Understanding the attitudes and emotions towards chocolate eating.

The second part of this doctoral research focuses on the personal characteristics that influence consumer behaviour. A large array of personal characteristics can be taken into account such as socio-demographics, habit, attitudes ... (Vermeir and Verbeke, 2008, Verbeke and Vackier, 2005). Since it is stated that the popularity of chocolate is related to the emotions it evokes with the consumer (Macht and Dettmer, 2006, Parker et al., 2006), this part focuses on the anticipated and perceived emotions related to chocolate consumption. The third research question thus asks:

RQ3: how do anticipated emotions affect the behavioural intention and behaviour of consuming chocolate?

The research conducted in chapter 4 showed that anticipated emotions and emotional beliefs are closely related to the intention to consume and the actual behaviour of consumers towards chocolate consumption. As chocolate is known to be a comfort food (Wansink et al.,

2003, Anonymous, 1975) that is related to emotions, this finding might be valid for other emotive food products. This finding opens up an array of possibilities on how consumer can be targeted by focussing on these emotional beliefs in marketing campaigns (Jiang et al., 2014).

The research also indicated that the Belgian and Hungarian consumers ground their consumption decision on different beliefs. Since the chocolate market is growing and evolving (Monotti, 2008), it is necessary to reveal what the drivers for consumption are in a cross-country setting. Understanding the differences between these beliefs, is valuable information for the marketers that need to commercialise these products as this can help a company in the segmentation of consumers and target them with a specific marketing campaign (Westad et al., 2003).

The study revealed that it is important to first arouse the intention to eat filled chocolate. This intention to eat is aroused before the consumers buy the product. Therefore the beliefs that are identified as important for motivating the consumers can be used in commercials. Next to that, marketers can influence the emotions of consumers by increasing the belief in resulting positive emotions after eating filled chocolate. Consequently, this is no longer only related to anticipated emotions but also to experienced emotions. These experienced emotions can be evoked by using and applying sensory marketing and thus letting consumers taste the product in the shop, spread the scent or play music that influences their emotions (Raz et al., 2008).

This raises the fourth research question:

RQ4: how do sensory profiles influence emotional profiles and affective ratings?

As shown in Part I both texture and flavours are important in the overall sensory experience when consuming chocolate. Thus, two sub questions are formulated as one study focuses on texture attributes and two other studies on flavour attributes:

What influence does a more positive emotional profile have on acceptance of chocolates? (RQ4a)

Do different flavours in chocolate evoke different emotional profiles? (RQ4b)

The first study in chapter 5 indicated that the three milk chocolates had significantly different sensory profiles. Moreover, the emotional profiles of these milk chocolates were also significantly different. Further analysis of the acceptance data indicated that products with emotional profiles consisting of more positive terms are significantly more accepted than other products. This is in line with previous research that indicated that a majority of emotional self-reports on food in published literature are positive since eating is basically a positive experience (Gibson, 2006, Desmet and Schifferstein, 2008) which is called the hedonic asymmetry (Desmet and Schifferstein, 2008). This corresponds to the idea that food products are designed to evoke positive emotions and thus attract consumers to buy and eat the product (Cardello et al., 2012). This was also confirmed in the other two studies in this chapter. When bringing the product to the market, it is important to know which positive

emotions a product evokes as enhancing these emotions will increase the acceptance of the product.

The following sub question was studied in the other two studies in chapter 5. However, the results of both studies are contradicting. In the first study, several significant differences were found in the emotional profiles of a mint and orange flavoured chocolate whereas in the other study only one significant difference was found between the plain dark chocolate and the raspberry flavoured dark chocolate. This can be attributed to the environment in which both tests were conducted. The first was conducted in a sensory lab whereas the latter was conducted during a local open-air fair. This confirms previous findings on effect of a laboratory environment on the results (Köster and Mojet, 2015) and the influence of context effect (Piqueras-Fiszman and Jaeger, 2014a, Piqueras-Fiszman and Jaeger, 2014b). These results show that the environment in which the experiment takes place has an impact on the possible results. Respondents in a sensory lab are probably more focused on the task at hand whereas this focus might be absent when conducting the research at an open air fair. This impact should be further analysed in future research.

The final study also compared the emotional profiles of chocolate based on tasting and on food name. The absence of significant differences contradicts the results found by Cardello et al. (2012) whose study showed differences between tasting foods and corresponding food names. However, as stated in the respective article, the conditions of the experiment with food names were different than the test with food tasting. Again, the importance of the context or environment in which the experiment is conducted needs to be considered when making conclusions based on gathered data.

Further analysis looked into the influence of gender, preference for a type of chocolate (white, milk or dark) and consumption frequency on emotional profiles. The difference between males and females was limited when tasting chocolates. This corresponds to previous findings in which no gender differences were found (Gutjar et al., 2015, Damasio, 2001, Robin et al., 2003). Moreover, prior preference for a specific type of chocolate also resulted in little differences in emotional profiling. As for consumption frequency, high frequent users indicated to have more intense positive emotions than medium and low users.

Finally this chapter also explored the relation between attitudes towards chocolate and the emotional profiles. The results indicate that individuals having a craving for chocolate, give positive emotional profiles to chocolate. Emotional eaters give a negative connotation to the word chocolate as they associate it with the guilty feeling they expect to have afterwards (Cartwright and Stritzke, 2008). Although they still have these negative feelings when they taste chocolate, the positive emotions increase (Fletcher et al., 2007) which makes it very difficult for these consumers to reject chocolate knowing that they will feel negative (guilty, unattractive, ...) after consumption (Macht and Dettmer, 2006). The emotional profiles as given by the 'non-emotional' eaters is significantly different from the other two groups as they give low values to all emotions in the study as these individuals do not perceive chocolate as emotional food.

The answer to the fourth research question is that differences in sensory profiles can result in different emotional profiles as perceived during and after consumption of chocolate and these emotions affect the acceptance of the products. More positive emotions increase the acceptance of chocolate. In these studies gender and prior preference had little influence whereas consumption frequency and attitudes had a significant impact on emotional profiles.

Part III: Taste as a key factor for preference

Research objective 3: Additional knowledge generated for integrating sensory analysis in new product development.

Whereas Part I focused on the objective and subjective product quality and Part II on the personal characteristics that influence consumer behaviour, this Part III provides more insights in how sensory analysis can be integrated in existing methodologies for product development or product improvement.

Chapter 6 uses both the voice of the company and voice of the customer. This leads to the fifth research question:

RQ5: what are the opportunities and bottlenecks when including sensory analysis in consumer-driven product development?

Grunert et al. (2008) indicated that innovation is only possible when knowledge is successfully transferred across specialized functions such as sales and marketing, product design, engineering and production. Therefore, an alignment of the different departments is necessary. To obtain this, a communication tool that can be used throughout the company and that includes all the necessary and relevant information in product development such as consumer preference, technological capabilities, products from competitors, processing parameters, consumer attitudes and marketing related aspects, should be developed. Several authors indicated that product development should be consumer-driven and therefore this should be integrated in this tool as well (Linnemann et al., 2006, Moskowitz et al., 2006).

QFD is indicated as one of the most complete and comprehensive methods for integrating the goals of many processes and aligning them to the consumer's requirements (Holmen and Kristensen, 1998). The first matrix HOQ in the QFD translates the consumer requirements into engineering targets (Benner et al., 2003b, Urban and Hauser, 1993, Cohen, 1995). The research indicates that the HOQ is a starting point for product development and can serve as a vehicle for dialogue to strengthen vertical and horizontal communication. The net effect of the HOQ should be that the items that drive the company's actions are based on consumer's requirements.

In this chapter sensory analysis was successfully integrated in the HOQ as illustrated with the case-study for fat bloom on filled chocolates. However, some items of the methodology are identified which make it difficult to apply the method in the food industry:

- A thorough understanding of the methodology is necessary to construct the HOQ.
- Data sets need to be centralised and relationships between these data sets should be identified.
- The large amount of data in the HOQ makes it difficult to work with and to present the findings to others.
- Filling some parts of the matrix is based on personal experience or literature.

These items increase the difficulty of using HOQ in the food industry as a tool for new product development. To overcome these items, an expert in the methodology is necessary and collaboration between different departments is crucial.

However, HOQ also provides some opportunities for product development. Garcia et al. (2007) points out that product development in the food industry is difficult, because food products cannot be described as a set of sensory attributes. It is the interaction between these sensory attributes that defines the consumer satisfaction. Garcia et al. (2007) comment that the possibility of defining these interactions is an advantage of the HOQ. The HOQ makes it possible to show that one engineering characteristic can affect more than one consumer requirement and vice versa. Combining other methods with HOQ can help to overcome the presented bottlenecks. The fuzzy set theory (Park et al., 2012, Kwong et al., 2007) can be used to fill in the matrix more objectively. The combination of HOQ and Chain Information Model (CIM) can result in higher success rates in product development (Benner et al., 2007). CIM can help to identify the necessary information for product development and facilitates information exchange in the food production chain (Benner et al., 2003a). By combining these two techniques, which cover the internal process of product development (HOQ) and the development process in the chain (CIM) with the consumer wishes as a starting point, possibilities for new product development can be revealed.

However, here only intrinsic attributes are incorporated in the product development although it is known that extrinsic attributes play a crucial role in the acceptance of a food product. The trade-off between these intrinsic and extrinsic attributes is discussed when answering the final research question.

Chapter 7 and 8 looks at the influence of both intrinsic and extrinsic attributes on actual choice of the final consumer. The sixth and final research question asks

RQ6: whether tasting is the most important attribute for consumer preference?

First, a review was presented on the previous applications of conjoint analysis in the food industry and the possibility of incorporating sensory analysis and more specific tasting in conjoint analysis. Second an experiment was set-up in which conjoint analysis with and without tasting was conducted to reveal the influence of tasting on final choice.

Including tasting in conjoint analysis requires a well-developed method and an extension with instrumental analysis to select the most fitting products to use in the conjoint analysis, is necessary (De Pelsmaeker et al., 2013a, Johansen et al., 2010a). This approach should tackle the first limitation when including tasting in conjoint analysis which is the limited amount of samples that can be used to keep the task manageable for the respondents.

Next, the total amount of attributes that can be included in the conjoint analysis is limited (Alriksson and Oberg, 2008a), thus prior knowledge of the most critical intrinsic and extrinsic attributes is required. This can be overcome by setting up a standard procedure (focus groups, quantitative data, literature review, ...) to select these attributes and related attributes levels.

Several authors have stated that the influence of some attributes such as price or taste can be overestimated when these characteristics are stressed in the questionnaire (Solheim and Lawless, 1996, Vickers, 1993). This indicates that combining extrinsic and intrinsic attributes in a conjoint analysis requires a good model and experimental design.

This experiment was set up to provide an answer to the last research question but also to find out if the objections as raised above can be tackled. The results indicated that by keeping the amount of attributes low, rewarding the consumers and retrieving the most important attributes through qualitative research, the bottlenecks were overcome.

The study confirmed the strong impact of tasting because including tasting as a stimuli presentation increased the importance rating for the attribute taste, and resulted in a broader range of the utilities between the taste levels. The results of the overall population indicated that the most preferred product would be a chocolate with sugar and from a premium brand. However, segmenting the respondents revealed that three distinct groups of respondents could be defined. This confirms results from previous studies which identified segments of consumers who make product choices based solely on sensory cues, whereas other segments indicate extrinsic cues as more important (Didier and Lucie, 2008, Mueller and Szolnoki, 2010).

This study confirmed that combining intrinsic characteristics by using tasting as a presentation stimuli, and extrinsic attributes of products in conjoint analysis can help to develop a holistic picture of purchase decisions and the underlying preference structure (Mesías et al., 2013). Moskowitz and Silcher (2006) already stated that conjoint analysis can be used to create totally new to the world combinations of product attributes and thus will lead to true consumer-driven co-creation and innovation. This is of key importance in the innovation driven economic environment of today.

Conjoint analysis can be an important tool when defining marketing strategies as it helps marketing professionals to understand the relative importance of product attributes (Carneiro et al., 2005). Not only can existing products be altered to fit the need of consumers but it will also help to outline the process to develop novel products for different consumer segments (Malhotra, 1999).

In conclusion, this part presented the possibilities and added value of incorporating sensory analysis in two methods that both present opportunities for consumer-driven product development. Whereas the QFD can be used as a communication tool over different departments and offers options to change the production, the conjoint analysis provides information on the possible combination of attributes to construct the product and market in the most appropriate way. If a conjoint analysis is conducted prior to QFD, the combination of the two methods can lead to new product development as the former gathers information on the composition of the product and the latter can define how this can be produced.

9.2. Research contributions

The major research contribution of this doctoral research refers to:

- the combined empirical research on the relationship between the objective and subjective product quality and the personal characteristics which can result in successful product development or improvement.
- the originality of looking and reviewing the possibility of incorporating tasting as a stimuli presentation in conjoint analysis and conducting the first experimental research to study the influence of tasting as presentation method in comparison to verbal description.
- the methodological adaptation of the theory of planned behaviour with the extended component of anticipated emotions and the follow-up research on emotional profiling of chocolate products and how this affects liking of these products.
- the examination of how the correlation between sensory analysis and instrumental analysis of chocolate products can lead to new insights on the product characteristics and the possibility of changing the process conditions based on this gained knowledge.

On overview of the scientific and industry contributions are presented in Table 9. 1.

Table 9. 1: Scientific contribution per contribution area and level of contribution

Contribution area	Contribution level	
	Extension	Innovation
<i>Methodological</i>	<p><u>Emotions:</u></p> <ul style="list-style-type: none"> Extended Theory Planned Behaviour with anticipated emotions <p><u>New product development:</u></p> <ul style="list-style-type: none"> Influence of Attitude to Chocolate Questionnaire on conjoint analysis 	<p><u>Relevance sensory analysis:</u></p> <ul style="list-style-type: none"> Development of a sensory wheel for chocolate products <p><u>New product development:</u></p> <ul style="list-style-type: none"> Conjoint analysis with tasting as presentation method and comparison with traditional conjoint analysis (verbal description)
<i>Empirical</i>	<p><u>Relevance sensory analysis:</u></p> <ul style="list-style-type: none"> Impact of fat bloom on sensory characteristics Insights in objective and subjective texture sensory characteristics <p><u>Emotions:</u></p> <ul style="list-style-type: none"> Identifying emotional profiles of products with different sensory properties and specifically flavours within one product category <p><u>New product development:</u></p> <ul style="list-style-type: none"> Incorporation of sensory analysis in conjoint analysis Identifying bottlenecks of incorporating sensory analysis and process parameters in house of quality 	<p><u>Relevance sensory analysis:</u></p> <ul style="list-style-type: none"> Evaluation of graininess of chocolate <p><u>New product development:</u></p> <ul style="list-style-type: none"> Possibilities and bottlenecks to incorporate tasting as a presentation method in conjoint analysis

This section describes the methodological and empirical contribution of the existing research on chocolate. These gaps underpin the scientific contribution of this doctoral research and provide justification for our study.

9.2.1. Methodological contribution

This doctoral research mainly uses existing data collection methods, such as the standardized questionnaire attitude to chocolate questionnaire (ACQ), the EsSense Profile® method or established models such as theory of planned behaviour (TPB). Further, common sensory analysis methods from both discriminative and descriptive analyses are used. Finally also conjoint analysis is applied in this doctoral research.

The first part of this doctoral research looks into the sensory characteristics of chocolate products. Traditionally when conducting sensory analysis on a food product, a list of sensory attributes is assembled from previous literature or qualitative research. Previous researchers already developed a sensory wheel for specific products which represents all the sensory attributes that are relevant for these products (Bérodier et al., 1997, Theron et al., 2014, Koch et al., 2012). These sensory wheels provide a non-limiting overview of attributes that are relevant and recognizable for consumers. Within this research such sensory wheel was set-up for chocolate products.

In order to analyse the influence of emotions on consumer behaviour, the model of theory of planned behaviour (TPB) was extended with an additional component 'anticipated emotions'. Many studies indicate that emotions have an influence on the final food choice and some have already acknowledged this in the TPB (Richard et al., 1996, Parker et al., 1992, Mohiyeddini et al., 2009) although never constructed similar as in this study. In this doctoral research, anticipated emotions are added as a separate component and predictor to intention and behaviour of the TPB in this study. Therefore, the research contributes to the growing literature on how decision makers regulate their intention and behaviour by providing evidence that the emotions seems to function as a trigger for the consumers of emotive food products. It is not the aim of this study to claim that TPB is insufficient for predicting consumer behaviour but to study if the explained variance of the model is higher when including a factor for anticipated emotions when studying the consumer behaviour towards chocolate.

The second method that is used is conjoint analysis. This method has been frequently used in the food industry because it can be a useful tool for new product development (Moskowitz and Silcher, 2006). Moreover, it predicts the future reactions of a consumer by measuring the stated trade-offs consumers make concerning preferences and their intention to buy a product (Green et al., 2001). In most of the studies, the respondents are segmented a priori on consumer characteristics or a posteriori on the results from the conjoint analysis (Helgesen et al., 1997, Naes et al., 2010b). In some studies, this segmentation is conducted based on the outcomes of an attitudinal questionnaire (Asioli et al., 2014). Traditionally, conjoint studies are set up in such a way that the conjoint part is followed by this attitudinal questionnaire

(Asioli et al., 2014). In the conducted conjoint task, the effect of answering an attitudinal questionnaire prior to the conjoint task on the results is studied. The ACQ is used as attitudinal questionnaire in this chapter (Benton et al., 1998). Instead of looking at the results of the factor and cluster analysis, the influence of the answering this ACQ is studied. Moreover, this research also tries to identify if the answers on the conjoint test differ between the respondents belonging to other clusters.

The final methodological novelty in this dissertation is the comparison study on the influence of using tasting as a stimulus in conjoint analysis instead of verbal instructions. Previous conjoint analyses focused more on extrinsic attributes instead of intrinsic attributes (Grunert, 2003a). Some researchers have looked at the sensory attributes but rarely as an integrated part of the conjoint analysis (De Pelsmaeker et al., 2013a) although never a comparison study was conducted with verbal description of these sensory attributes. This experiment is the first study that conducted the experiment with and without tasting simultaneous in order to find differences in the stimuli presentation.

9.2.2. Empirical contribution

The empirical contribution of this doctoral research is to be found primarily in the application and integration of sensory analysis in product development.

Part I provides insights in how knowledge on sensory aspects can lead to possible alterations of the process or product composition. A first topic is fat bloom on filled chocolates. As this problem is considered to be the number one quality problem in the confectionary industry (Depypere et al., 2009b), the microstructural aspects has been subject to numerous research studies (Afoakwa et al., 2009b, Afoakwa et al., 2009c, Lonchampt and Hartel, 2004, Altimiras et al., 2007, Choi et al., 2005, Galdámez et al., 2009, De Graef et al., 2005). This study focuses on the effects of fat bloom on the sensory characteristics. By incorporating different storage temperatures and ingredients, insights can be provided on what the impact is of these parameters is on the altering sensory characteristics. This can be valuable information in tackling the problem of fat bloom.

The second topic explores the differences in objective and subjective sensory characteristics. The perception filter as defined by Risvik (2001) explains that consumers observe sensory characteristics often differently than intended by the company. Understanding these differences and the interaction between subjective evaluation of consumers and their acceptance can also help in defining the necessary objective sensory characteristics that a company needs to take into account when developing new products.

The third topic covers an interesting and innovative use of sensory analysis namely as a tool to guide process improvement. Here the focus is on particle size within chocolate products. A cut-off value is used in the industry (Engelen et al., 2005, Afoakwa et al., 2007) however the origin of this value is not supported by sensory studies. By letting consumers evaluate several chocolates with different particle sizes, it is clear that this cut-off value can be altered which impact the processing conditions of chocolate. This study thus proves that altering a process

is possible without the risk of decreasing the acceptance of consumers if a structured sensory analysis is conducted.

The three discussed topics demonstrate the value of using sensory analysis when improving a product or a process.

Part II studies the interrelation between the sensory aspects and the consumer behaviour and how the first can influence the latter. An increasing amount of studies indicate that next to liking, an emotional profile can provide new information to product developers (Cardello et al., 2012, Thomson et al., 2010, King et al., 2010, Gutjar et al., 2015). Different emotional profiles for food products has been set-up in previous studies. Here, the novelty is that all products are within one product group. First, different types of milk chocolate are used and then differences between dark chocolate with different flavours is studied. The research here studies if these products also differ in emotional profile and which emotions are drivers for acceptance. These differentiations can provide insights for product development and marketing strategy (Jiang et al., 2014)

Finally, in the **Part III**, a critical review is provided on two current methodologies in product development and more specifically on how these two can incorporate sensory analysis. The first method incorporates the vision from the company, the technical requirements and the voice of the customer or the consumer requirements in one framework (Chan and Wu, 2002). This framework is called the House of Quality (HOQ) which is the first matrix in the matrix-generating process within the Quality Function Deployment method. Here, this HOQ is assembled by using sensory characteristics and process parameters as technical requirements. In the past, sensory characteristics were combined with instrumental parameters, whereas here different process parameters were combined. This experiment was executed to uncover the bottlenecks of this method which possible keeps this method from being more regularly applied in the food industry.

The second method is already described in the methodological part namely conjoint analysis. A review on the application of this method in the food industry presents examples of previous studies in which sensory analysis and conjoint analysis has been combined (De Pelsmaeker et al., 2013a). Moreover, the review identifies the possible drawbacks of the incorporation of sensory analysis in the conjoint task. However, it also shows the importance of finding a solution to these drawbacks because the sensory characteristics of a product need to be taken into account when developing a new product as this is an essential part of the purchase intent (Haddad et al., 2007, Helgesen et al., 1998). Therefore, it summarizes possible solutions which are applied in a follow-up experiment in which tasting is integrated as a presentation method in the conjoint task.

This doctoral research validates the opportunities, identifies the bottlenecks and studies the effects of integrating sensory analysis in new product development. This delivers a scientific underpinning for the use of sensory analysis in the food industry. The scientific field should be made more aware of these applications and keep these in mind when conducting research.

9.3. *General conclusion for the food industry*

The overall objective of this doctoral research is to identify opportunities how sensory analysis can play a part in the innovation process or at least serve as a tool to gather information for improving the features (marketing, product or process) of a product. Some issues are given here how sensory analysis can be successfully implemented in new product development.

Sensory characteristics are without a doubt intertwined with product acceptance. Nobody will repurchase a product which was not 'tasty' or even make a purchase of a product that does not look good (e.g. fruit and vegetables) in the supermarket. Therefore any company who sells a consumer good should take into account the sensory characteristics and associated acceptance of that specific product. However, some researchers have indicated that evaluation of sensory characteristics does not explicitly declare the purchase, consumption, or market success of a product (Garber Jr et al., 2003). This research showed that a certain gap exists between sensory tests and probability of product success in the market. Therefore some researchers argue that the value that sensory researchers could have to a firm and to a product's ultimate market success can be limited (Garber Jr et al., 2003).

This doctoral research confirms what was stated before by Wansink (2003) namely that modifications of sensory methods and combinations with other analyses could help to obtain better insights on factors that influence the purchase, consumption, and market success of a product. These adjustments are critical for a successful consumer-driven product development.

Throughout the research, all conclusions were linked to the Stage-Gate® method. Figure 9. 2 gives an overview where different methods in sensory analysis can be incorporated in order to enhance the product success in the end.



Figure 9. 2: Options to insert sensory analysis in the Stage-Gate® process

1. It is clear that whenever sensory analysis is used as the only source of information, a producer will never receive a complete image of the consumer needs. The sensory wheel can help in this qualitative step in which information is gathered to discover new ideas for product development. In this step, it is important listen and watch what the customer indicate as the most important sensory characteristics.
2. Full understanding of the intrinsic attributes and extrinsic attributes that the consumer requires in a product is the following step. Today these intrinsic attributes

are not limited to sensory characteristics but expanded to the amount of sugar, fat or salt in the products as consumers grow more conscious on what they eat (Mozaffarian, 2013). For the extrinsic attributes, price and brand are still the main factors although convenience, labelling and many others are increasingly important (Enneking et al., 2007). Grasping therefore the most important attributes and levels of these attributes is thus a necessity to gather the elements to draft a hypothetical product. As demonstrated here, conjoint analysis can be of great value in this first step.

3. A critical step in new product development is the production of this product. Here the final sensory characteristics need to be kept in mind. A change in the processing or the ingredient composition can lead to shifts in the sensory characteristics. As illustrated, the HOQ can be used as a tool not to lose track of these interactions. During or after production, these sensory characteristics need to be measured. As demonstrated in this research, two options are available: instrumental and sensory analysis. Nowadays, most companies use instrumental analysis due to the sensitivity and reliability of machines. However, this research clearly indicated that the choice between one of these analyses or even the combination of both should be based on the question that was raised. The high failure rate in the food industry demonstrates that relying on instrumental analysis or only using sensory analysis as a tool in final quality control is insufficient. In most cases, the combination works synergistically and can provide additional information on possibilities of further innovation. The correlation between objective measurements by machines or a trained panel can be of critical value to optimize the formulation of the product.
4. In the testing phase, it can be interesting to look on how the customer perceives the product. This information can be linked to the information gathered in the previous step. At this point the feedback from a consumer panel can help to decide if the product can be launched or to still make changes to the product to alter problems that were not captured in the previous stages of the process. For SMEs, it might be difficult to implement this point three due to time and money constraints. For these companies this step is even more crucial as they can still stop the launch of the product at this point. Large companies can at this point conduct, large scale consumer tests to receive quantitative data on the acceptance and preference of the newly developed product.
5. When launching a new product, the marketing mix for this product needs to be defined. A frequent mistake is that a food product is made or appropriate for 'everyone' or slightly better 'for persons from age X to Y'. This is obviously incorrect as indicated in this research. Not only do socio-demographic elements are important, but also beliefs, attitudes and as shown here emotions either anticipated or perceived. Based on these aspects, specific segments can be found. It is possible that these segments have a different sensory preference. In conclusion, segmentation of the population and marketing variables that could lead to different sensory outcomes,

need to be combined with sensory tests. Again sensory analysis can be of crucial importance to determine the most fitted product for a specific segment.

6. Finally, in a post-launch review, it can be determined as a follow-up how well your product is doing. This can then be used as Quality Assurance aspect but at this stage, it is too late if your product is not performing as it should be.

The above considerations show that sensory analysis should be inserted as a tool during product development instead of limiting its use to quality control or quality assurance (Muñoz, 2002). This doctoral research shows that sensory analysis grasps and helps to understand the attributes of a product that consumers believe to be important and take into account in acceptance of the product.

9.4. Limitations

The results reported in this doctoral research should be critically evaluated as the limitations of the study need to be taken into account when interpreting the results and its contributions.

The limitations regarding **Part I** are related to the instrumental analyses that were used. These were rather limited as only colour measurements, texture (hardness) measurements, SFC, DSC and PSD were used. These all related to appearance and texture attributes. Therefore the correlation between the instrumental and sensory analysis is limited as the instrumental parameters could only be linked to these specific sensory parameters. No aroma or flavour analyses were incorporated in this part due to limited time and funding. However, this would have meant an additional value to the results in Part I.

Part II consisted mainly of sensory analysis with consumers which leads to certain limitations that need to be considered. First, there may have been a selection bias in the sample due to the on-line questionnaire which could be corrected via random selection of consumer representatives for the whole Belgian population.

Moreover, the socio-demographic profile of the Belgian and Hungarian consumers is different. This might make it difficult to compare the results from both countries. However, in both countries respondents were selected based on consumption of filled chocolates. Therefore, it might be possible that the profile of filled chocolate consumers is different in these two countries.

Second, some studies on TPB have included constructs such as past behaviour (Carrus, 2008) and habit (Honkanen et al., 2005) and indicated that these were important in predicting intention and behaviour. These constructs were not included in the given study as such. Therefore some might argue that the constructs used in this research were too limited although the main aim was to study the influence of anticipated emotions on the model.

Third, the objection could be made that for the three experiments that identified the influence of sensory characteristics on emotional profiles, different chocolates were used which makes the extrapolation of the results impossible.

In **Part III**, the experiment conducted for the final chapter was exploratory and thus this study can be extended in several ways. A limitation of this study is the number of attributes and attribute levels used in the conjoint analysis. When this method should be used for product development, more attributes and attribute levels need be included in the study to get a better picture of the product that needs to be produced. This is conflicting with the amount of products that a consumer can taste in this conjoint analysis. This problem can however be tackled by conducting thorough instrumental analysis and sensory analysis with a trained panel in order to characterise the products. Then a selection of the products can be made so that they span the sensory space. The key attributes that make up for product success are numerous and could not all be taken into account in this study.

Due to the comparative nature of this experiment, the design was kept simple. It can be argued that the complexity of the study is too limited to mimic a real situation, however this was not the aim of the study given that so many respondents needed to be reached in order to give clear results on the impact of including tasting as a stimuli presentation. Future research with more attributes and a corresponding lower amount of respondents to keep the experiment manageable and within certain price limits should be conducted.

9.5. *Directions for future research*

As the doctoral research encompasses three different parts, some directions for future research are presented for every part.

Part I indicates that flavours are indicative for differences between chocolate products. Future analysis of flavour differences between chocolates from different origins is thus recommended. Skelly (2015) indicated that developed countries should be targeted with new chocolates of premium quality keeping in mind the consumer needs. By focusing on specialty flavours, these needs can be fulfilled (Tholen, 2015). As this research indicates that values for aroma and flavour attributes are closely related, it could be sufficient to perform either aroma or flavour analysis with a trained panel. Future research could combine this analysis from a trained panel with instrumental aroma or flavour analysis. Some research was already done in this field (Tran et al., *In Press*), but it could be interesting to develop an aroma/flavour wheel for chocolate in which the inner tier presents the aroma/flavour components and the outer tier the chemical components. This could evolve in a very applicable tool for the chocolate industry.

Moreover, Part I also focused in the intersection between sensory analysis and instrumental analysis. Although some researchers have already done experiments to retrieve thresholds for sensory attributes (Lima Filho et al., 2015, Harwood et al., 2012, Prescott et al., 2005), it might be interesting to look at the gap between the thresholds of instrumental analyses and sensory analyses with both trained and consumer panels. As the study on graininess shows, these results can lead to both product and process innovation. The combination of knowledge on technology and microstructure of food products and sensory evaluation of products might provide insights that together lead to product development.

Part II studies the relation between emotions and consumer behaviour. In chapter 4, the concept of anticipated emotions was included in the TPB. Given the novelty of the current findings, replication is warranted before any definite conclusions can be drawn. Further research could compare the fit of models in which the position of the construct anticipated emotions differs to identify the rightful place within the model. This kind of study should be conducted in collaboration with psychologists in order to underpin the model. Moreover, Perugini and Bagozzi (2001) suggest to consider further theory broadening and deepening by incorporating other constructs that might be important to the consumer such as previous experience with the product and habit.

Finally, as the TPB has received criticism (Köster, 2009, Köster and Mojet, 2007) but has also been applied multiple times (Blanchard et al., 2009a, De Bruijn, 2010, Pawlak et al., 2009, Honkanen et al., 2005, Vermeir and Verbeke, 2008, Zhang et al., 2009, Bogers et al., 2004) a deeper understanding of this model would be interesting. Therefore, the set-up of the model used in this study could be applied in further research to study if the anticipated emotions are also important in the behaviour of eating daily foods or healthy food products. This extended

model could result in a decrease of the predictive power when applied for other products such as daily products (e.g. bread) or healthy products (e.g. yoghurt).

Moreover, Jiang et al. (2014) indicated that seven characteristics have an effect on emotions of which only three (gender, liking effect and attitudes) were taken into account in this doctoral research, future research might look at the other aspects. It would also be interesting to have more in-depth analysis on how gender differences, user frequency or attitudes influence emotional profiles of food products.

In the field of emotional research, two important things should be noted. First, is the method of measurement. Although several methods have been developed (Cardello et al., 2012, King and Meiselman, 2010, King et al., 2010, King et al., 2013, Thomson et al., 2010, Desmet et al., 2000, Spinelli et al., 2014b), it remains difficult to grasp the emotions of consumers during or after consumption. When these methodologies are combined with sensory evaluation of food products, it becomes an even more challenging task for consumers. Therefore, a new tool should be developed to measure emotions and sensory characteristics together. A first step is set by Schouteten et al. (2015) with the EmoSensory® Wheel. The validity and the applicability for different food products should be determined in further studies.

Second, all the measurements above are self-reported measurements. In order to really understand the emotions related to food products, brain activity should be measured during consumption of food products. Then the results from for example the EmoSensory® Wheel and the data from measuring brain activity can be compared to study the consistencies between these results.

Finally, further analysis could be conducted in which one part would focus on anticipated emotions and another on perceived emotions. The comparison between anticipated emotions and expected emotions based on packaging or tasting was already conducted for chocolate by Ng et al. (2013a) but the development of a framework on how these two concepts are influencing each other could provide more insights in how these two concepts influence behaviour.

Part III shows how sensory analysis can be incorporated in two methods for new product development. Moskowitz et al. (2008, 2006) stated that there is an increasing demand for a well-defined procedure that, in a structured way, leads to new product development. With the HOQ such a method is available although the research here suggests that it should be broadened with more information on the consumer such as what drives a consumer to prefer a certain product or the attitude of a consumer has towards a certain product. This can then be taken into account when developing the technical aspects of the product. Moreover, the HOQ should be combined with other methodologies to have more objective input information.

The review on conjoint analysis indicated that this method can also be further improved to become a hands-on marketing tool for the food industry. Although the main aim of conjoint analysis is to assist with product development, it is rarely used for this purpose. Research that

combines sensory characteristics and conjoint analysis might help to identify ideal products for specific consumer segments. Development of such a method would be a valuable tool for the industry in terms of future innovation in order to survive in a competitive environment.

As this final experiment with conjoint analysis was exploratory, this can be extended in several ways. It can be argued that the amount of attributes that were used was too low to mimic a real situation, however this was not the aim of the study given that so many respondents needed to be reached (Raz et al., 2008). The selected key attributes that make up for product success are numerous and therefore could not all be taken into account in this study. Future research with more attributes and a corresponding lower amount of respondents to keep the experiment manageable and within certain price limits should be conducted. This study could also be conducted with other products than chocolate to validate the influence of taste or by expansion other sensory attributes on consumers' choice. That will also give data to compare the impact of influence between different products or product groups.

As this doctoral research indicated that sensory analysis should be involved when developing new product, the need for an overall method that looks at new product development from start (idea generating) over processing to final acceptance of the consumers is still present. The development of such a tool or method can be realised by interviews with the producers, stakeholders and policy makers in the food industry and a thorough study of the existing models for new product development.

Appendices

Appendix I:

Guideline for the focus groups in chapter 2

Experimental design

There are 5 white chocolate, 8 milk chocolate and 9 dark chocolates included in the focus groups. The brands are replaced by three-digit codes.

Introduction (2 min)

Good afternoon/evening everyone. First, I want to thank everyone for joining this focus group. The aim of today's focus group, is to collect sensory characteristics that are important for consumers when they buy a chocolate product. You see that there are a large amount of chocolate samples gathered on the table. During the next discussion, you will be able to look, smell and taste chocolates. It is important to think of characteristics that differ one product from another. During this session, we will focus on appearance, texture, aroma and flavour. You all have received some papers on which you can write down some things during this overall session.

Appearance (15 min)

First, we will look at the appearance of chocolate. I would like to ask you to close your eyes and think of your perfect piece of chocolate. Try to visualize this piece of chocolate. What does it look like? Which characteristics are very important to you? Please write these characteristics down. It does not matter which words you use, as long as it describes what you are thinking of.

Now you are presented with three series of chocolate. First white, second milk and third dark chocolate. In every series, different brands are included with different prices. However, we have blinded these chocolate from their package and coded them with a three digit code and they are randomly ordered.

White chocolate

The first series contains white chocolates. When looking at this series, which parameters were present in your 'ideal' chocolate? Which parameters can be added? Please note these down as well. If you would now have to choose a favourite chocolate from the series, which one would you pick and why? Why did you eliminate the other? Please also write this down.

Identical procedure was conducted for milk and dark chocolate.

Texture (20 min)

The following group of sensory attributes that we look at, is texture. Again, we try to find out which texture attributes are important when you buy, choose or consume a piece of chocolate. We focus on texture and not on the aroma or taste or flavour of these chocolates. We will look at these characteristics further in this focus group.

Again, close your eyes and think of your ideal piece of chocolate. Write down on the paper, what you want to experience when you bite a piece of chocolate, when you let it melt on your tongue, when you bite it to pieces, when you swallow it... Try to put those sensory expectations in wording as good as possible. We want to know what is important for you relate to the texture of chocolate.

White chocolate

Now we will proceed similar as to what we did for the part of 'Appearance'. Again we will start with the white chocolate. Now you can bite a piece of the chocolate and indicate which chocolate you prefer in terms of texture. Why do you choose this chocolate and why not another piece? Which attributes do you prefer and which do you dislike? Try to describe this as good as possible. Focus on the bite, the feeling on the tongue and palate, the swallowing... and not on the taste or smell of the chocolate.

Identical procedure was conducted for milk and dark chocolate.

Aroma (20 min)

After looking at appearance and texture, we now proceed with aroma, the smell of chocolate. Again try to describe the aroma of your ideal chocolate. Try to be as complete as possible. Even if you do not know the exact aroma, try to give related words or sentences that could describe that aroma.

White chocolate

Now we will proceed a little different. First, I would like you to smell all the chocolates and indicate the specific aromas that you perceive for each chocolate. Which chocolate aromas do you notice? Please write them down. This might be a difficult task so please concentrate. Do not think of ingredients of the chocolate, but on what you smell.

Then we go on as before, so please indicate which chocolate do you prefer based on the aroma? Why did you pick out this one? Why did you eliminate the others? Also, write down these aroma attributes.

Identical procedure was conducted for milk and dark chocolate.

Taste/Flavour (15 min)

This is the last part of this focus group, the taste or flavour of a chocolate. You all know the basic tastes: sour, sweet, salt, and bitter and umami. Here you do not need to think of umami. Think of the other four basic tastes and ask yourself if your ideal chocolate tastes as one of these four basic tastes? Write down which one you want to taste in your ideal chocolate and which you don't want to taste. Now also think of other flavours that are important? There is more than these four basic tastes that drives you to choose a specific chocolate. Please write down these flavours.

White chocolate

Again we work similar as to what we did with the aromas. Please taste all the chocolates and write down the tastes and flavours that you perceive during tasting of these chocolates. Again, don't think of the ingredients but focus on what you perceive.

Finally pick one chocolate that you prefer. Why did you pick this one? Why did you eliminate the others? Write down the tastes and flavours that were involved in your decision.

Identical procedure was conducted for milk and dark chocolate.

Closing and thanking (2 min)

So this was the end of this focus group. I hope you all enjoyed it and perhaps learned something. I want to thank you for your participation in this focus group.

Appendix II:

Guideline for the focus groups in chapter 9

Introduction

First, the moderators asks the participants to fill in their nametags and place these on the table in front of them.

Good afternoon everyone, today we will conduct this group session and the purpose of this session is to investigate different characteristics influencing the choice of chocolate.

The group discussion is going to be recorded on audio. This copy can only be used for research purposes; everything said here will be confidential. The information will remain anonymous. There are no good or bad, right or wrong answers, we are interested in everybody's own view.

We would like everyone to be involved in the discussions. You can ask questions from each other and react to each other's opinion. We would like to ask express your opinions clearly, and please do not talk all together.

Warm up

Please, tell us your First Name, than what you think it is important to know about you. (e.g. age, married/status, children, age of children, hobby....) Write this also down on the paper.

- What is your **first thought** about chocolate?

Understanding of the chocolate category dynamics

- Exploration of the fundamental meaning of chocolate:
 - What role does chocolate play in your life?
 - What is the emotional and psychological meaning of chocolate?
- Explorations of the fundamental needs and motivations that drive the purchase and use of chocolate.
 - What do you look for in chocolate? What are the benefits and the points of satisfaction for you?
 - What are your barriers to eat chocolate?
- Behaviour with respect to chocolate:
 - When do you eat chocolate mainly?
 - What chocolate products do you consume?
 - Which other products would/could replace chocolate?
 - Where do you tend to eat chocolate? How come?

- Why do you buy chocolate (situation, seeing the product, etc.?)?
- What is the role of the supermarket, the product, brand, taste, format... in those occasions?
- Are there any other important aspects for the purchase?

Perception and experience of the ideal chocolate

Think about your **perfect image** of chocolate (regardless of colour?). How does it look and which are the main characteristics for you? Write it down in the first section of "ideal chocolate" on your **paper**. Please express what you find important, it doesn't matter if you can't express it in exact words.

Now, each of you may present its perfect piece of chocolate in half a minute.

After hearing all the descriptions, are there any extra characteristics for your ideal chocolate? Write them down in the "second section of ideal chocolate".

Perception and experience of current products offer in the chocolate category

- Open exploration of the current products
 - Which different chocolate products do you know? Why do you consume those products (or why not)? Where do you buy those products?
 - What do you miss/can't find on the market?
- Comparison with products (Present a piece of chocolate)
 1. What are the **main characteristics** of this chocolate? Write it down on paper.
 2. **Now, we will compare the piece of chocolate you got with your ideal chocolate**
 - If you see this chocolate, how close does it get to your ideal chocolate on a scale of 1 to 10? Which are the similarities and differences?
 - Are there any extra aspects that you thought of for your ideal chocolate? Write them down in the section "Product – Ideal chocolate – extra aspects".
 3. In this next step, you must compare the piece of chocolate you got with the chocolate that you normally **consume**
 - If you see this chocolate, how close does it get to your ideal chocolate on a scale of 1 to 10? Which are the similarities and differences?
 - Are there any extra aspects that you thought of for your ideal chocolate? Write them down in the section "Product – Normally consumed – extra aspects".

Establish final list characteristics of choice of chocolate

In this last step, you make a list of five items that influence your choice of chocolate when you buy chocolate and rank them.

End

Is there anything that might be important related to the choice and characteristics of chocolate that hasn't been discussed yet?

Now, we have finished the discussion. Thank you for your cooperation and answers.

Scientific Curriculum vitae

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Education

<u>2009 to date</u>	<u>Doctoral research</u>
2012 to date	Academic Assistant at the department Agricultural Economics
Summer 2011	Internship at Energizer: Personal Care (Milford, Connecticut, USA) <i>Intern at the consumer research centre: New product development Skills in consumer testing, sensory testing and statistical analyses</i>
2009 - 2011	Doctoral researcher Seventh European Framework Project: ProPraline
<u>2004-2009</u>	<u>Higher education</u>
2007-2009	Degree: Master of Bioscience engineering: Food Science and Nutrition, Major in Food Technology and Nutrition Institution: Ghent University, Ghent Dissertation: Influence of inter-esterification on the behaviour of mixtures of grape seed oil with palm oil and palm fractions. Internship: Kristallisatie van (non)-laurische vetten, cacaoboter en

	CBE's (Barry Callebaut, Wieze)
2004-2007	Degree: Bachelor of Bioscience engineering: Chemistry and Food Technology
	Institution: Ghent University, Ghent
	Dissertation: Antidepressiva in opmars: nieuwe (bio)chemische ontwikkelingen
<u>1998-2004</u>	<u>Secondary education</u>
	Degree: Science-Mathematics
	2002-2004: Science – Mathematics
	2000-2002: Mathematics – Latin
	1998-2000: Latin
	Institution: Sint-Maartensinstituut, Aalst

Extra courses

2011	Statistics for Sensory and Consumer Science (NOFIMA, Norway)
2010	Advanced Academic English Writing Skills (UGent)
2009	Quality Research Skills (UGent)
2009	Advanced Methods of Marketing Research I (UGent)

Publications

Articles in peer-reviewed journals

- 2015** De Pelsmaeker, S., Gellynck, X., Delbaere, C., De Clercq, N., Dewettinck, K. (2015) Consumer-driven product development and improvement combined with sensory analysis: a case-study for European filled chocolates. *Food Quality and Preference*, 41, 20-29
- Schouteten, J.J., Hans De Steur, De Pelsmaeker, S., Lagast, S., Ilse De Bourdeaudhuij, Gellynck, X. (2015) An integrated method for the emotional conceptualization and sensory characterization of food products: the EmoSensory® Wheel. *Food Research - International*, 78, 96-107
- Schouteten, J.J., Hans De Steur, De Pelsmaeker, S., Lagast, S., Ilse De Bourdeaudhuij, Gellynck, X. Impact of health labels on taste perception and emotional profiling: A consumer study on cheese. *Nutrients*, 7 (12), 10251-10268
- 2013** De Pelsmaeker, S.; Schouteten, J.J., Gellynck, X. (2013) The consumption of flavored milk among a children population. The influence of attitudes and the association of brands with emotions. *Appetite*, 71 (1), 279–286
- De Pelsmaeker, S., Dewettinck, K., Gellynck, X. (2013). The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis. *Trends in Food Science and Technology*, 29 (2), 108–115

- 2011** Januszewska, R., Pieniak, Z., Verbeke, W., De Pelsmaecker, S., Delbaere, C., Depypere, F., Kuti, T., Hegyi, A., Dewettinck, K., Gellynck, X. (2011) Food Choice Questionnaire revisited in four countries. Does it still measure the same? *Appetite*, 57, 94-98.

Articles in national journals (A3)

- 2014** Borovsak, K., Gellynck, X., De Pelsmaecker, S., Kuhar, A. (2014) Does consumer preferences exceed initially indicated wishes? The case of dessert topping. *Acta Agriculturae Slovenica*, 104, 5-14
- 2013** De Pelsmaecker, S., Gellynck, X., Delbaere, C., De Clercq, N., Januszewska, R., Hegyi, A., Kuti, T., Depypere, F., Dewettinck, K. (2013) The influence of different storage conditions and fat bloom on sensory characteristics of pralines. *Food Science and Law*, 4 (2), 45-51

Conference paper

- 2015** Hegyi, A., Kuti, T., Kertész, Z., Sebők, A., De Pelsmaecker, S., Gellynck, X., Lehota, J. (2015) Consumer behaviour at the impulse product with product defect. *5th International Conference on management, Management, leadership and strategy for SMEs' competitiveness*, Gödöllő, 18–19th June

Submitted articles in peer-reviewed journals

- 2015** De Pelsmaecker, S., Juvinal, J.G., Lagast, S., Schouteten, J.J., Dewettinck, K., Gellynck, X. Influence of chocolate texture on Belgian consumers' emotions and affective ratings. *In Journal of Food Quality (Under review)*
- De Pelsmaecker, S., Schouteten, J.J., Lagast, S., Dewettinck, K., Gellynck, X. Is taste the key driver for purchase intent of consumers? A conjoint analysis study. *In Food Quality and Preference*
- Lagast, S., Hans De Steur, Schouteten, J.J., De Pelsmaecker, S., Gellynck, X. Emotional conceptualizations in blind sensory evaluation. A comparison of consumers' perceptions of regular sugar and alternative sweeteners in dark chocolates. *In Food Research International*

Attended international conferences and seminars with oral and poster presentations

2015

11th Pangborn Sensory Science Symposium, 23-27 August 2015, Svenska Mässan, The Swedish Exhibition & Congress Centre, Gothenburg, Sweden

- Oral** De Pelsmaecker, S., Schouteten, J.J., Lagast, S., Dewettinck, K., Gellynck, X. Is taste the key driver for purchase intent of consumers? A conjoint analysis study.
- Poster** Schouteten, J.J., De Steur, H., De Pelsmaecker, S., Lagast, S., De Bourdeaudhuij, I., Gellynck, X. Effect of health labelling on expected and actual taste perception of cheese.

Schouteten, J.J., Vella, A., De Clercq, N., Van Durme, J., Lagast, S., De Pelsmaecker, S., Dewettinck, K., Gellynck, X. Linking instrumental, sensory and emotional evaluation of flavoured chocolates.

Schouteten, J.J., De Steur, H., Lagast, S., De Pelsmaecker, S., Gellynck, X. Linking emotions and sensory attributes of traditional food products. An application of the CATA approach in a study on children.

Lagast, S., De Pelsmaecker, S., Schouteten, J.J., Gellynck, X. Local food products in health care facilities: Elderly sensory acceptance of a local food menu

Lagast, S., De Steur, H., Schouteten, J.J., De Pelsmaecker, S., Gellynck, X. Emotional connotations of consumers in blind sensory evaluation of chocolates with normal and alternative sweeteners.

2014

Food Structure and Functionality Forum, 30 March – 02 April 2014, Amsterdam

Oral De Pelsmaecker, S., Behra, J., Schouteten, J.J., Dewettinck, K., Gellynck, X. Difference in threshold detection of graininess in chocolate: machine vs human.

Poster Schouteten, J.J., De Pelsmaecker, S., Juvinal, J.G., Gellynck, X. Influence of chocolate texture on Belgian consumers' emotions and affective ratings.

Lagast, S., Schouteten, J.J., De Pelsmaecker, S., Gellynck, X. Sensory differences between low-fat and regular yogurt measured by instrumental analyses and consumer evaluation.

SenseAsia 2014 The Asian Sensory and Consumer Research Symposium, 11 – 13 May 2014, SingEx, Singapore

Poster Schouteten, J.J., De Pelsmaecker, S., Lagast, S., Gellynck, X. Sensory evaluation of fresh, canned and frozen French beans by children.

Lagast, S., Schouteten, J.J., De Pelsmaecker, S., Gellynck, X. Relation between sensory characteristics and consumer preference for traditional Belgian cheeses.

Schouteten, J.J., De Pelsmaecker, S., Lagast, S., Gellynck, X. Can emotions deliver additional information on the informed liking of flavoured milk by children?

2013

VBFoodNet 2013 conference: Postharvest Technology, Food Chemistry and Processing: "Developing The Supply Chain Towards More Healthy Food", 11-13 November 2013, Hanoi University of Agriculture, Trauquy, Gialam, Hanoi, Vietnam

Poster Tuyet, M.N., De Pelsmaecker, S., Schouteten, J.J., Gellynck, X., Dewettinck, K. Potential of milk polar lipids in chocolate products: sensory and instrumental evaluation.

2012

5th European Conference on Sensory and Consumer Research 'A sense of inspiration', 9-12 September 2012, BERNEXPO, Bern, Switzerland

Poster Colley, B.S., De Pelsmaecker, S., Nicoll, G. Somatosensations experienced in male shavers after shaving the face and neck.

2011

9th Pangborn Sensory Science Symposium, 4-8 September 2011, The Sheraton Centre Toronto Hotel, Toronto, Canada

Poster De Pelsmaecker, S., Gellynck, X., Januszewska, R., Delbaere, C., De Clercq, N., Depypere, F., Dewettinck, K., Kuti, T., Hegyi, A. Application of Theory of Planned Behaviour in Belgium and Hungary on emotional food.
De Pelsmaecker, S., Gellynck, X., Januszewska, R., Delbaere, C., De Clercq, N., Depypere, F., Dewettinck, K., Kuti, T., Hegyi, A. Quality evaluation of fresh and bloomed filled chocolates in House of Quality.
 Kuti, T., Hegyi, A., Gilbert, C., De Pelsmaecker, S., Januszewska, R. Comparing Belgian and Hungarian preferences for chocolate pralines and their acceptance of product defects such as blooming and cracking.

2010

Schokotechnik, conference for new technologies in chocolate manufacturing, 7-9 December 2010, Cologne, Germany

Poster Delbaere, C., Depypere, F., De Clercq, N., De Pelsmaecker, S., Januszewska, R., Gellynck, X., Dewettinck, K. Influence of ingredients and storage on sensory characteristics of fresh and bloomed pralines.
De Pelsmaecker, S., Januszewska, R., Hegyi, A., Kuti, T., Delbaere, C., Depypere, F., De Clercq, N., Dewettinck, K., Gellynck, X. Influence of ingredient and storage on sensory characteristics of fresh and bloomed pralines.
 Kuti, T., Hegyi, A., De Pelsmaecker, S., Januszewska, R., Delbaere, C., Depypere, F., De Clercq, N., Dewettinck, K., Gellynck, X. Understanding consumer acceptance and preferences towards Chocolate Pralines.

4th European Conference on Sensory and Consumer Research 'A Sense of Quality', 5-8 September 2010, Palacio Europa, Vitoria-Gasteiz, Spain,

Poster De Pelsmaecker, S., Januszewska, R., Gellynck, X., Dewettinck, K. Differences in detection time in fat bloom formation in pralines.
De Pelsmaecker, S., Januszewska, R., Gellynck, X., Dewettinck, K. Influence of emotions on sensory perception in milk chocolates.
 Januszewska, R., De Pelsmaecker, S., Gellynck, X., Dewettinck, K. Emotional consumers prefer unusual flavours.
 Januszewska, R., De Pelsmaecker, S., Gellynck, X., Dewettinck, K. Sensory perception of home-made products by highly-involved consumers.

Januszevska, R., De Pelsmaeker, S., Gellynck, X., Dewettinck, K.
Understanding variety-seekers and neopholic tasting traditional products.

Supervision master students

2011-2012	Gil De Clercq: 'De correlatie tussen instrumentele en sensorische analyse van chocolade'
	Joachim Schouteten: 'Invloed van merk, emotie en sensorische aspecten op het consumeren van melkdranken bij kinderen'
	Thomas Van der Meeren: 'De invloed van de socio-demografische factoren op het consumentengedrag van wijn en de impact daarvan op het beleid van de Belgische wijnbouwer'
2013-2013	Joel Juvinal: 'Influence of chocolate texture on Belgian consumer's emotions and affective ratings'
2013-2014	Valerie Courtois: 'Chocolade met en zonder stevia : identificatie van smaakperceptie en gedrag van consumenten'

Scientific support in projects

2008-2010	ProPraline: EC-FP7-SME 'Structure and processing for high-quality chocolate pralines -ProPraline'
2010-2013	Taste Classes: Interreg IVa Flanders – The Netherlands project 'Smaakklassen als hefboom voor innovatie bij KMO/MKB's uit de voedingssector'
2012-2015	Green Food Industries Lifelong Learning Programme ' European master "Green Food Industries
2013-2015	PDPO Vlaanderen (Plattelandontwikkeling): As 3 gebiedsgerichte werking – project 'Smaakbeleving als hefboom voor marktinnovatie'
2013-2015	Leader MLS – project 'Crowdsourcing en innovatie voor kmo's en detailhandel'
2015	Interreg project 'Taste2Seas fase 2'
2014-2016	Flanders Food project 'FINESWEET - In het spoor van Stevia: Functionaliteit van natuurlijke bulkstoffen in combinatie met nieuwe natuurlijke zoetstoffen in zoetwaren'

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